# GRAFTON TO BRISBANE NATIONAL RAILWAY LINK

NOMINATION FOR RECOGNITION

AS

NATIONAL ENGINEERING HERITAGE LANDMARK

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PREPARED FOR

ENGINEERING HERITAGE AUSTRALIA (NEWCASTLE)

Cover illustration taken from a postcard issued at the time of the Clarence River bridge opening. This is an early example of what, today, would be called "photoshopping": Kingsford Smith's *Southern Cross* was never known to have been photographed in conjunction with the bridge.

# CONTENTS

## Appendix A

Letter of approval from Australian Rail Track Corporation

## Appendix B

Papers on the design and construction of the Clarence River bridge by J.W. Roberts (Transactions of Institution of Engineers Australia, volume 13, 1932, pp. 369 to 381 and 405 to 414.)

## Appendix C

Heritage listings for elements of the railway

# GRAFTON TO BRISBANE NATIONAL RAILWAY LINK

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## NATIONAL ENGINEERING HERITAGE LANDMARK

## INTRODUCTION

This proposal has been prepared by Bill Jordan, Rod Caldwell and John Brougham on behalf of Engineering Heritage Australia (Newcastle).

The railway from South Grafton to Brisbane was the first link between Australia's state capital cities using standard gauge track and heralded the first significant cooperation between the States and the Commonwealth in working towards a national railway network.

The railway, which was completed in 1932, had significant "firsts" for Australian railways:

- the first (and only) double deck, road and rail, opening bascule bridge;
- the first spiral track used to reduce grades;
- the first of the works built under the Commonwealth and States Uniform Gauge Railway Project;
- it raised important constitutional difficulties in addressing national infrastructure projects;
- it achieved Commonwealth and State cooperation for directing major infrastructure works to the benefit of national defence requirements, as well as meeting the commercial needs of the States for development and rural transport.

# HERITAGE MARKER NOMINATION FORM

The Administrator

Engineering Heritage Australia

Engineers Australia

Engineering House

11 National Circuit

BARTON ACT 2600

**Name of work: Grafton to Brisbane National Railway Link**

The above-named work is nominated to be recognized as a National Engineering Heritage Landmark

**Location, including address and map grid reference if a fixed work:**

Railway line from Grafton to Brisbane (South Brisbane Station) as shown on the locality map on the next page including the road/rail bridge over the Clarence River at Grafton.

**Owner (name & address):** Rail Corporation New South Wales, PO Box K349, Haymarket NSW 1238; Queensland Rail, 305 Edward Street (GPO Box 1429), Brisbane Qld 4001; lessee New South Wales section Australian Rail Track Corporation, PO Box 10343 Gouger Street, Adelaide SA 5000.

The owners and lessee have been advised of this nomination and the relevant letter of agreement for the ceremony at Grafton is attached (Appendix A).

**Access to site:** At railway stations and overbridges along the route, otherwise under owner escort

**Nominating Body:** Engineering Heritage Australia (Newcastle)

Chair of Engineering Heritage Australia (Newcastle)

Date: 31/3/2009


*Figure 1: Map showing the route highlighted.*

# THE FRUITS OF FEDERATION
# THE GRAFTON BRISBANE UNIFORM GAUGE RAILWAY AND CLARENCE RIVER BRIDGE

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## 1. The Origins of the Project

The Grafton to South Brisbane railway was the first tangible result of the movement towards standardisation of railway gauges in Australia. At first it was railway professionals, headed by the commissioners of Australia's state government-owned railways, who sought to resolve the problem. Immediately after Federation in 1901 they began meeting regularly and in 1905 established a common loading gauge for future construction and sought to move towards uniformity of track gauge.[1] From 1910, and more especially after 1920, it became a political movement as well. The Grafton to South Brisbane railway was the first railway built co-operatively by two states and the Commonwealth with funding from all three governments. A specially created Railway Council on which the three governments were represented supervised its construction and its purposes were overtly national. Defence and ease of communication between states were the railway's aims.

Apart from the Commonwealth's own Trans-Australia Railway from Port Augusta to Kalgoorlie, built between 1912 and 1917, the Grafton to South Brisbane Railway was the first genuinely national railway project in Australia. For as long as economic considerations as seen by their owners, the state governments, drove railway policy, little could be expected in the way of the national integration of railways or gauge standardisation. However, following Federation the political situation north of Australia became more volatile and in 1910 Britain's first soldier, Field Marshall Kitchener, visited to analyse Australia's defence, writing an influential report which formed the basis of future defence planning.[2]

His scathing observations on the shortcomings of Australia's state-based railways were to be quoted for decades:

> Railway construction has resulted in lines which appear to be more favourable to an enemy invading Australia than to the defence of the country. Different gauges in most of the states isolate each system, and the want of systematic interior connexion makes the present lines running inland of little use for defence, though possibly of considerable value to an enemy who would have temporary command of the sea.[3]

Concerns about defence and lofty national aspirations differed greatly from the aims of railway construction in the colonial era, which focussed on developing the colonies' economies in certain ways. In the case of New South Wales, the colony's development based on a centralisation of economic activity on Sydney had been the main aim of railway policy, expressed in the high priority given to completing the three radial main lines to their termini at Albury, Bourke and Wallangarra.

Queensland Railways had followed a different railway policy. Their aim was to connect ports with their hinterlands as cheaply as possible to open these for settlement. Economy had been the reason for the choice of a narrow gauge of 3ft 6in. In 1865 Queensland became the first place in the world where the construction of long-distance railways to such a narrow gauge was undertaken. Eventually there were no fewer than eleven separate railways in Queensland,

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1 The loading gauge determines the distance at which structures may be located from the kinetic envelope of rolling stock as it moves along track or, more simply, the height and width of rolling stock. The track gauge is the distance between the inside of the heads of the rails. The three main track gauges in Australia in 1920 were 5ft 3in (1600mm, Victoria and South Australia), 4ft 8½in (1435mm, NSW and Commonwealth) and 3ft 6in (1067mm, Queensland, Tasmania, parts of South Australia and Western Australia).

2 Field Marshal Viscount Horatio Herbert Kitchener of Khartoum, Memorandum on the Defence of Australia, Melbourne, Government Printer, 1910.

3 Field Marshal Viscount Horatio Herbert Kitchener of Khartoum, Memorandum on the Defence of Australia, *Commonwealth Parliamentary Papers*, 1910, Vol 2, p 85. Kitchener's observation was quoted slightly inaccurately in *The Argus*, 8 July 1926. The inaccuracies (in phrasing rather than meaning) indicate that it was a phrase which the journalist remembered rather than looked up, illustrating how well known it was.

each serving a different port. In 1887 the first Queensland railway (Ipswich to Toowoomba, opened in sections between 1865 and 1869) was extended to Wallangarra on the New South Wales border. Two years later the completion of the New South Wales line across the New England Tableland from Newcastle to Wallangarra (or Wallan-Garra as the NSWGR curiously spelt it) created a rather circuitous rail route on two gauges between Sydney and Brisbane

Meanwhile, Queensland also had been building narrow-gauge lines southwards from South Brisbane, which also ultimately reached the New South Wales border. The first opened to Southport in January 1889, and six months later a branch opened from Ernest Junction to Nerang. There the terminus remained until its extension to Tweed Heads, right on the border, in September 1903. Tweeds Heads station was in fact just south of the border in New South Wales. The railway's main function, although not its aim, was the burgeoning tourist traffic it created. Kirra and Coolangatta became the first surf beaches within easy reach of Brisbane by train, and weekend traffic was enormous. However, it was not a railway built for surfers and holiday-makers, even if these became its main users.

The Nerang to Tweed Heads extension was designed and built after Federation. Although it was not until 1905 that the commissioners of all Australian state railways agreed to a common loading gauge as the new national standard, Queensland Railways built the railway to the New South Wales loading gauge with clearances and structures allowing easy conversion to standard gauge, including bridges, cuttings and a tunnel capable of accommodating the larger New South Wales rolling stock.[4]

Queensland's aims in building the Nerang to Tweed Heads line were a mixture of the new national approach of linking the nation's capitals and the old colonial approach of grabbing a neighbouring colony's trade. These were contradictory and this incoherence explains why the Tweed Heads line failed to achieve either of its aims, although it certainly became a great way of getting to the beach on a hot Brisbane Sunday. The New South Wales parliament twice referred a Murwillumbah to Tweed Heads railway to its Standing Committee on Public Works In both 1904 and 1915 the proposal was rejected, but the discourse was very different. In 1904 New South Wales feared that the railway could divert traffic from the far north coast, to Brisbane whereas, in 1915, the railway was rejected not because it would create a through route to Brisbane, but for exactly the opposite reason: because it was not the best option for such a route.

The opening of the Casino to Kyogle branch on 25 June 1910 raised another and clearly superior way of linking the New South Wales north coast with Brisbane by rail. This could be achieved by the extension of the Kyogle line up the valley of Grady's Creek, across the McPherson Range which formed the state border, into the upper Logan River valley, where a small narrow gauge railway network already existed. Queensland Railways had opened a branch from its Southport line at Bethania Junction to Beaudesert in 1888 and light tramways owned by the Beaudesert Shire Council were completed from Beaudesert to two termini at Lamington in September 1910 and Rathdowney in March 1911.[5]

The Kyogle branch was proving to be a great success which prompted an exploratory survey north from Kyogle to Richmond Gap on the Queensland border, with the aim of opening up more country. William Hutchinson, the Chief Engineer of Railway and Tramway Construction, undertook the survey himself and recommended a line following the Richmond River and Grady's Creek to Richmond Gap, gaining height 'by means of a spiral tunnel'.[6]

Hutchinson was so enthusiastic that he wanted this to be built to much higher standards than the Casino to Kyogle line and designed 'an express line', with a maximum grade of 1 in 80 and a minimum radius on curves of 15 chains, to be laid with 80 pound per yard rails, fully ballasted, and with steel bridges on concrete piers. Its aim was not merely to develop the country, but to run heavy express passenger and goods trains through to Brisbane. His proposed spiral was an engineering extravagance of the kind the NSWGR had never had the money for in the nineteenth century, but which in the new century it embraced with enthusiasm.

NSWGR Deputy Chief Commissioner John Harper supported Hutchinson's Kyogle route to Brisbane as early as March 1914, pointing out that the distance would be reduced from 725 miles via Wallangarra to 608 miles:

4 Evidence of Colonel Charles Evans, given at Brisbane, 15 May 1916. Royal Commission on Public Works – Proposed Beaudesert-Kyogle Railway, Report, *Queensland Parliamentary Papers*, 1916-1917, Vol 3, p 737.

5 R. Ellis and K. McDonald, *The Beaudesert Shire Tramway*, Melbourne, Light Railway Research Society of Australia, 1980 is a history of these tramways.

6 John Harper, Deputy Chief Commissioner NSWGR to A. Griffith, NSW Minister for Public Works, 31 March 1914, quoted in evidence of Jonas Molesworth Stawell, Deputy Chief Engineer of Railway and Tramway Construction, given at Sydney 13 April 1916. *Queensland Parliamentary Papers*, 1916-1917, Vol 3, p 552.

> This saving in distance is an important feature having regard to the utility of the route for express train service and, being more inland would be favoured by the Defence Department for strategical reasons in preference to the coastal route via Murwillumbah and Tweed Heads.[7]

Even before the war broke out in August 1914, the NSWGR was taking Kitchener's criticisms of Australia's railways seriously, and was seeking to address them.

Meanwhile, the Queensland government was making its own analysis of the situation and in 7 February 1916 appointed a Royal Commission to investigate a Beaudesert to Kyogle railway. At its head was William Gillies, latterly of Tintenbar near Lismore, now member for Atherton, and a strong believer in closer links between New South Wales and Queensland.

Gillies and his fellow Royal Commissioners went to Sydney, where their proposal met with great enthusiasm. An NSWGR official made it clear that he expected through passenger traffic to be lucrative:

> We have to meet with very keen competition by the boats, and it is our desire naturally to secure as much of the passenger traffic as we can. The better and quicker service, therefore, that we can give, the better chances we shall have of competing with the steamers.[8]

Defence was also a serious consideration. There was no point in creating more places where the railway would be vulnerable to attack by sea, observing that, 'Of course the military don't like the Hawkesbury Bridge at all.' The army agreed. It had hosted a conference on strategic railways in Sydney on 6 May 1915, a little over a week after the first Anzac Day, which had recommended construction of a line to Brisbane via Kyogle as the highest priority.[9]

In Queensland, Railways Commissioner Charles Evans was sufficiently interested to travel by car from Brisbane to Kyogle via Beaudesert on 22 March 1916, accompanied by his Chief Engineer, Richard Sexton. Evans wanted to build a standard gauge line from a new station at South Brisbane to the border tunnel, totally separate from the existing narrow gauge railway. He still thought it possible that traffic might one day justify both the Kyogle and Tweed Heads links to New South Wales, although he preferred the inland route. He estimated the line to Richmond Gap tunnel would cost about £750,000[10], while conversion of the line from South Brisbane to Tweed Heads would cost much more at £1,115,000. This was because north of Ernest Junction (and especially on the oldest section between Yeerongpilly and Beenleigh) it had been built cheaply with sharp curves and light bridges.[11]

Gillies' Royal Commission recommended that Queensland construct 71 miles of standard gauge railway from South Brisbane to the tunnel at Richmond Gap conditionally on New South Wales building the railway from Kyogle to Richmond Gap. The report argued that 'a first-class express line should be continued from capital to capital', probably the first time such an aspiration had been articulated for an Australian railway; and advised that, at least at first, the NSWGR should operate the line with its rolling stock. Its overall conclusion was that 'in building new lines, especially lines such as this, the aims should be to make them serve the dual purpose of meeting the developmental needs of the State and the strategic needs of the Commonwealth.'[12]

Thus, by 1916 both Queensland and New South Wales had agreed on the general merits of the route through Kyogle, its superiority over a link between Murwillumbah and Tweed Heads, and the desirability of a shorter and faster railway between the two capitals than the original route through Wallangarra. A railway through the sub-tropical wilds of the McPherson Ranges began to be seen as a great national work.

## 2. Federalism and the 1921 Royal Commission

In 1920 the epicentre of thought and action on completing a coastal route from Sydney to Brisbane shifted from the backwoods of the border country and the committee rooms of the New South Wales and Queensland parliaments

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7 Harper to Griffith31 March 1914. *Queensland Parliamentary Papers*, 1916-1917, Vol 3, p 552.

8 Evidence of Charles Austin Hodgson given at Sydney 13 April 1916. *Queensland Parliamentary Papers*, 1916-1917, Vol 3, p 546.

9 Evidence of Charles Evans, *Queensland Parliamentary Papers*, 1916-1917, Vol 3, p 739.

10 No attempt has been made in this document to convert pounds to dollars as the relative values of the works make the conversion meaningless

11 Evidence of Charles Evans, *Queensland Parliamentary Papers*, 1916-1917, Vol 3 pp 739-740. Those sharp curves between Yeerongpilly and Beenleigh continue to slow Queensland Railways' otherwise very fast Gold Coast trains to this day.

12 Royal Commission on Public Works – Proposed Beaudesert-Kyogle Railway, Report, *Queensland Parliamentary Papers*, 1916-1917, Vol 3, pp 535-543..

to the national capital in Melbourne. The Premiers' Conference held in Melbourne in July 1920 was the first after the signing of the Treaty of Versailles, the formal restoration of peace, and the return of Prime Minister William Morris Hughes from Europe. At this conference, the nation set about defining its goals for the peace. Although there were war wounds to cauterise, optimism abounded.

In this context, the Commonwealth put railways and their role in defence at the top of the national agenda, referring the issue of standardising their gauge to a Royal Commission of two international engineering experts chaired by an Australian.[13] The initiative came from Hughes, whose wartime experiences understandably had made him obsessed with defence issues. He believed the key to preventing the tragic experience of war in Australia was military preparedness, for which a uniform railway gauge was essential.

The state governments, however, were unenthusiastic and some at least hoped the Royal Commission would fail. Formally appointed on 21 February 1921, the Royal Commissioners gathered in Melbourne to be briefed by Hughes. They were an impressive group. Frederick Methvan Whyte (1865-1941) was General Mechanical Engineer of the New York Central Railroad and inventor of the Whyte system of steam locomotive classification.[14] The British member, Rustat Blake (1871-1940) was both a civil and locomotive engineer of wide experience, whose business partner had

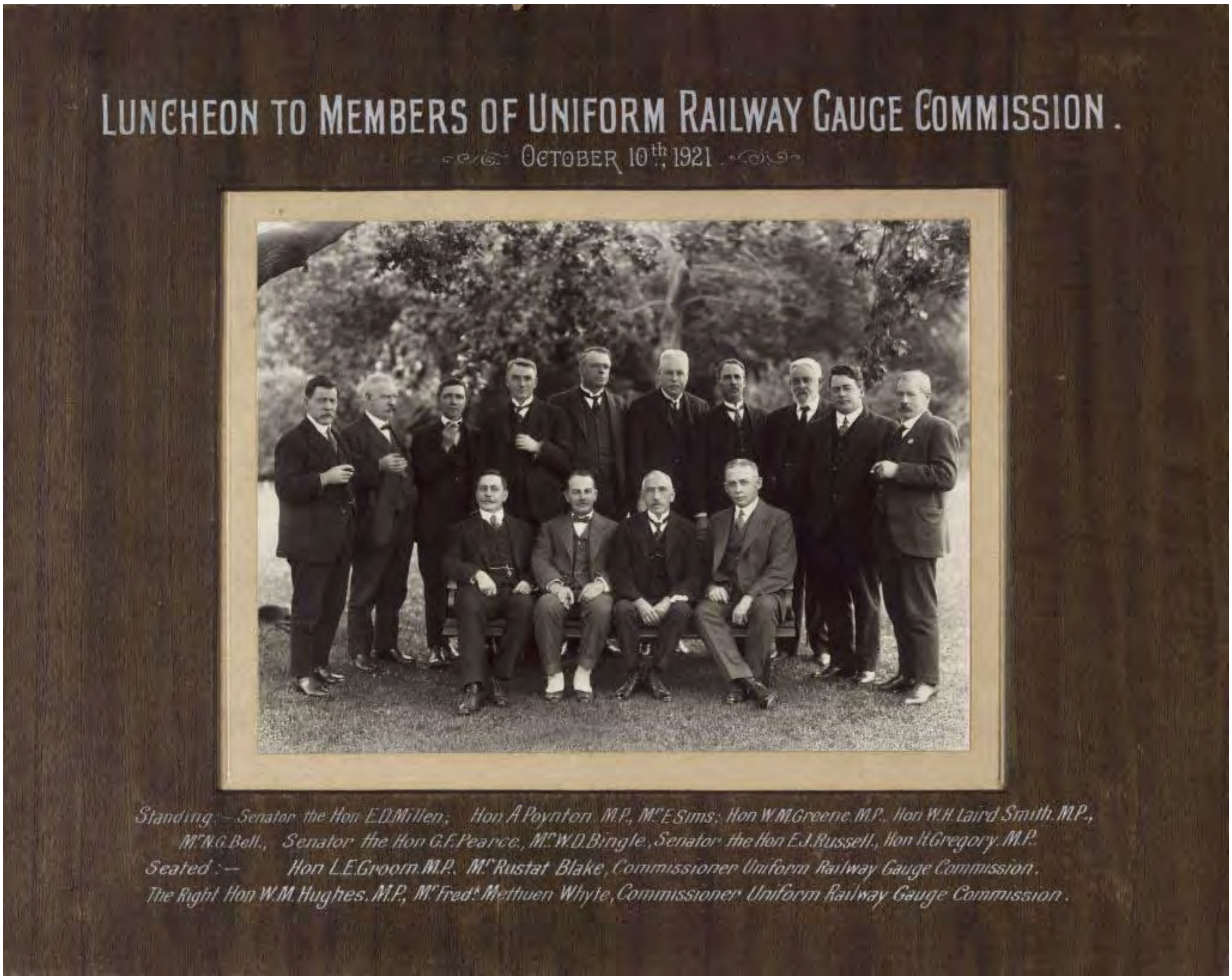


*Figure 2*

been Brigadier General Sir Alexander Gibb, founder of Britain's largest engineering consultancy company and a former head of both military and government civil engineering for the United Kingdom.[15] So Blake and Whyte were men at the very summit of the railway engineering profession. The Australian chairman was Sydney businessman John Joseph Garvan (1873-1927), an astute polo-playing bachelor who later chaired the Commonwealth Bank. Garvan had

13 *The Argus* [Melbourne], 25 September 1920.

14 *The Argus*, 13 February 1921.

15 'Obituary, Rustat Blake', *Journal of the Institution of Civil Engineers* (London), 14. 8 (October 1940)

spent part of his childhood on his father's family property 'St Helena' near Byron Bay and knew the New South Wales north coast well.[16]

The Commonwealth posed Garvan, Whyte and Blake five questions:

> 1. Which railway gauge should be adopted in Australia, and the reasons for selection of the one recommended?
>
> 2. What is necessary to be done in order to unify the gauges of the railway systems of Australia?
>
> 3. What will be the estimated costs of unifying the gauges of–
>
> (i) Main trunk lines;
>
> (ii) All lines;
>
> Including and showing separately–
>
> (a) Alterations to existing railways and structures;
>
> (b) Any new lines necessary;
>
> (c) Adjustments to rolling stock?
>
> 4. The order in which the work should be carried out and the methods by which it should be executed and controlled?
>
> 5. Whether a third rail or any mechanical device should be utilized; if so, what device upon what sections, and estimated cost?[17]

The State Railway Commissioners in effect had answered the first question by agreeing on the desirability of standard gauge at their 1905 meeting, a decision confirmed by the Commonwealth when it adopted this gauge for the Trans-Australia Railway in 1912. Unsurprisingly, the Royal Commission confirmed this decision. Although there was about as much 5ft 3in gauge trackage in Australia as standard gauge, it considered the latter superior for two main reasons. First the cost of conversion was less. Second, assuming a common loading gauge, more powerful locomotives could be built for standard gauge than broad gauge track, because their cylinders could be 3¼ inches greater in diameter (half the 6½ inch difference in track gauge). Cylinder diameter, along with boiler capacity, effectively determines a steam locomotive's power.[18] Its answer to question five was unequivocally negative.

The Royal Commissioners were not asked to report on funding, potential traffic, or return on investment of uniform gauge conversion projects. This proved to be their report's great weakness, since these were the issues which had always concerned state governments (and before them colonial governments) when deciding what railways to build and not build. Their answer to question two was that sections of 5ft 3in gauge and 3ft 6in gauge line should be prioritised for conversion. They took as the prime aim the creation of a through standard gauge link between Fremantle and Brisbane, although, since they were not asked, they made no estimates of traffic on the railway, the return on investment in gauge standardisation, or its wider economic benefits.

Indeed, the military significance of gauge standardisation always seemed to be foremost in the thoughts of the Royal Commissioners. While they were deliberating, the Inspector-General of Defence, Major General Sir Charles Chauvel, released his annual report, which began with this observation about the inadequacies of Australia's railways:

> The present railway system included several weak links so serious and so obvious in their nature that an enemy would be practically certain to avail himself of the strategic advantages accruing to him from the interruption of one or other of these vulnerable sectors. Sir Harry Chauvel considers that the linking up of our capital cities by railways beyond striking distance from the coast and the establishment of a uniform gauge throughout the Commonwealth, are matters of paramount importance.[19]

They prepared estimates of costs for five options, including two transcontinental routes, described as Routes A and B. All five options involved conversion of the Kalgoorlie to Fremantle 3ft 6in gauge railway to standard gauge; the construction of a new standard gauge railway from Port Augusta to Port Pirie (to circumvent the circuitous and mountainous narrow gauge route through Terowie and the Pitchi Richie Pass); a standard gauge route from Port Pirie to Wodonga; and a new Kyogle to South Brisbane standard gauge railway.

16 *The Argus*, 13 May 1921; *Australian Dictionary of Biography*, Vol 8, pp 627-628.

17 Parliament of the Commonwealth of Australia, Report of the Royal Commission on the matter of Uniform Railway Gauge, Prepared by command and Ordered to be printed, Melbourne, 13th October 1921. State Records of New South Wales (hereafter SRNSW), Series 15668, Item 7, p 3.

18 *Ibid*, p 15. The superiority of standard gauge was illustrated in a diagram showing possible cylinder diameters on broad and standard gauge locomotives, assuming the overall width limit of 10 feet as specified in the 1905 loading gauge.

19 *The Argus*, 12 August 1921.

Their first option, Route A, provided for conversion of the existing main lines between Adelaide, Melbourne and Wodonga. The second option, called 'Route A modified', included conversion of the branch lines from these main lines as well. The third option, Route B, involved a new line across northern Victoria and conversion of the Melbourne to Bendigo line to provide access to Melbourne. This would reduce the overall distance from Fremantle to Brisbane but make access to Melbourne circuitous from both west and north. These three options would cost £17,550,000, £18,579,000 and £19,583,000 respectively. Naturally, the alternatives in Victoria were the most contentious part of the report. Their fourth option included conversion of all 5ft 3in gauge railways in Victoria and South Australia and was estimated at £21,600,000. The fifth option was for conversion of all mainland railways and would cost £57,200,000.[20]

The fourth question was also contentious, as it determined priorities for expenditure and would involve creating a new authority to manage the project. The Royal Commissioners advised that the work 'should be controlled by one sole authority' headed by a 'Director, in whom large and final powers of decision should be invested.'[21] Such a proposal naturally would attenuate state control over railways as provided for under the federal constitution, and the failure of much of the report to be implemented is attributable as much to this threatening recommendation as to its lack of any analysis of the economics of its proposals.

So far as priorities were concerned, the report was politic and optimistic, although unrealistic, in its suggestion that, 'Work can be started in all of the States at the same time.'[22] The priorities for each state were outlined clearly, and those for New South Wales and Queensland were modest and promised the greatest result for the least investment, not that the report stated as much overtly. The specific recommendations were, for New South Wales:

> The coast line by way of Newcastle, West Maitland, Macksville, Kyogle and Richmond Gap needs a large bridge at Grafton, which should be started first, but with its construction can progress the construction of new track and improvement of present track West Maitland to Richmond Gap and the tunnels through the McPherson Range. This is a line with easier gradients, and much to be preferred, from an operating stand-point, to the present line from West Maitland to Wallangarra.[23]

And for Queensland:

> The new station in Brisbane and the new line from Brisbane to Richmond Gap, and the tunnels, should be started promptly, and all the work carried on together. The new rolling stock should be joint stock with New South Wales…[24]

The Commissioners also wanted 'an emergency line further from the coast and independent of the Hawkesbury River Bridge', and so advised that New South Wales build the already approved Binnaway to Werris Creek railway. This would complete an inland route from Sydney and Melbourne to Wallangarra via Werris Creek which would be less vulnerable to enemy military action than the coastal railway. North of the border, it advised conversion of the Wallangarra to Brisbane railway to standard gauge, either on its existing route through Toowoomba or on a new shorter alignment from Warwick through Maryvale to Brisbane. That choice was to be left to Queensland, where the merits of a direct railway from Warwick to Ipswich, known as the *Via Recta*, were already a matter of constant, and ultimately fruitless, debate. Their highest priority was clear: 'the line by way of Kyogle is recommended, and the emergency line to be provided later… The work on the tunnels [through the McPherson Range] should be put in hand promptly.'[25]

The state premiers greeted the report with a resounding public indifference, probably masking private hostility. The Commonwealth had agreed to pay twenty percent of the costs of the work, while the states were to pay for the remainder on a *per capita* basis. The Commonwealth recommended the Royal Commission's fourth option – conversion of all broad gauge railways and extension of standard gauge to Brisbane and Fremantle at a cost of £21,600,000 – to the November 1921 Premiers' Conference. The costs and expenditure on a government by government basis were:[26]

| **Railway** | **Cost of Works** | **Expenditure** |
|---|---|---|
| Western Australia | £5,030,000 | £1,078,103 |
| Commonwealth | £67,000 | £4,320,000 |

20 *Ibid*, pp 4-6, also Appendix III, pp 26-39.

21 *Ibid*, p 10. The proposed Director's massive powers were outlined in more detail in Appendix 4, pp 39-41. They would have terrified every state government.

22 *Ibid*, p 8.

23 *Ibid*, pp 7-8.

24 *Ibid*, p 8.

25 *Ibid*, p 34.

26 Table from *Canberra Times*, 16 September 1927.

| | | |
|---|---|---|
| South Australia | £4,674,000 | £1,632,292 |
| Victoria | £8,324,000 | £4,939,349 |
| New South Wales | £1,657,000 | £7,094,388 |
| Queensland | £1,848,000 | £2,535,868 |
| **Gross totals** | **£21,600,000** | **£21,600,000** |

The premiers piously expressed support but hypocritically voted to do nothing. For Victoria and South Australia, it would mean spending money to make handling their internal traffic more difficult. For New South Wales it would mean spending more money than any other state, all of which, apart from cost of the Grafton-Richmond Gap line, would be spent in other states. The premiers reneged on what they had agreed to do in July 1920 when they discovered the cost. It was a distressing revelation of the weaknesses of the Australian federal system, probably the worst in the Commonwealth's history before or since. Hughes was so disgusted he refused to make any comment.[27]

For decades, even to the present, newspapers and public opinion around the country have excoriated the premiers of 1922 for their selfishness, narrow-mindedness and short-sightedness. A *Canberra Times* 1927 editorial, prompted by reports of good progress on the one project undertaken, is typical:

> All authorities are agreed that sooner or later unification of the Australian railways must be undertaken. They are all agreed that immense advantages are to be derived from having a single gauge throughout Australia. At the same time it is apparent that every year the cost of the work must increase materially. Every mile of new line built in any State but New South Wales adds to the cost. Had the work been undertaken when the plans were made in 1921 it would be approaching completion to-day. Now it has still to be faced, with the extra cost for shirking the issue.[28]

Despite such criticisms, it is difficult not to have some sympathy for the premiers' position. For Victoria and New South Wales in particular, the disadvantages of gauge standardisation in many respects outweighed the advantages. Victoria may have gained a little additional traffic from the Riverina if its system was converted, but the costs and inconvenience of conversion would have been enormous. There was so little interstate goods traffic in 1921 that it hardly seemed worth the trouble.

## 3. The Grafton-South Brisbane Railway as First Fruits of Standardisation

Despite the overwhelming negative response from the states to the Royal Commission's report, there was one specific proposal about which the two states concerned showed a glimmer of support: a standard gauge railway from Kyogle to South Brisbane.[29] The Hughes Nationalist government collapsed in late 1922, and with it the sense of urgency about defence. However, the Minister for Works and Railways in the new Bruce-Page government was Percy Stewart, the Country Party member for Wimmera. Stewart was leftist by Country Party standards and, unlike most Country Party members, close to Hughes. He was also national in outlook and as a teenager had worked as a 'water-joey' during construction of the Mildura line, so he had no fear of building railways through the wilderness.[30]

Moreover, Stewart's party leader, Earle Grafton Christmas Page, was from Grafton and for him the Clarence River Bridge and the Grafton-South Brisbane railway were not just desirable national works – they were personal passions.[31] Stewart realised nothing could be achieved in Victoria and little in South Australia, and that Hughes' proposal to convert their railways to standard gauge was dead. He came up with a more modest scheme and convened a meeting of railway ministers in September 1923 to discuss two proposals, estimated to cost £3,500,000 and £4,500,000 respectively. First was the Kyogle-South Brisbane railway and associated upgrading of the railway between Grafton and Kyogle. The second was a railway from Port Augusta to Hay. [32]

Victoria and South Australia still refused to contribute a penny and the conference dissolved in disharmony and acrimony. The Port Augusta to Hay railway was dead but hope remained for the link to Brisbane. Stewart was resolute

27 *The Argus*, 4 November 1921.

28 *Canberra Times*, 16 September 1927.

29 *The Argus*, 3 November 1921.

30 *Australian Dictionary of Biography*, Vol 12, pp 92-93. 'Water-joey' is the Victorian term. A boy with the same job, bringing drinking water to the men and boiling their billy, was called a 'nipper' on the NSWGR.

31 John O'Hara, 'The Entry into Public Life of Sir Earle Christmas Grafton Page 1915-21' (B.A. Hons thesis, University of New England, 1969).

32 *The Argus*, 20 September 1923.

and could see that New South Wales and Queensland were willing to be involved in a project promising mutual benefit. He invited them to a conference a few weeks later, offering that the Commonwealth would pay the share of the cost of the new railway owed by Western Australia, Victoria and South Australia, which those states refused to pay.

Stewart daringly hosted this conference in Canberra, not yet the capital. The relatively short connection between Kyogle and South Brisbane would offer clear national benefits, had passionate regional support on both sides of the border, and was viewed favourably by the relevant state governments in Sydney and Brisbane. The military liked it too. Given that rare combination of political support, agreement to construct the railway came quickly.

On 14 April 1924 Prime Minister S.M. Bruce and New South Wales Premier Sir George Fuller met in Sydney to discuss terms. Fuller wanted the Grafton bridge to be part of the joint funding arrangements for the railway to Brisbane, but Queensland and the Commonwealth refused.[33] A week earlier, Queensland acting premier William Gillies had stated in Brisbane that, although the Grafton bridge was 'the stumbling block to the linking of South Brisbane with the northern rivers of New South Wales by standard gauge railway, he understood that the refusal of the Commonwealth and Queensland Governments to see eye to eye with New South Wales would not be fatal to the project.'[34] Gillies had chaired the Royal Commission on the railway back in 1916 and was a total enthusiast for the project. Moreover, he had only moved from Tintenbar to Atherton as recently as 1910 and his brother was member for Byron Bay in the New South Wales Legislative Assembly.[35] He was therefore well informed about opinion in New South Wales. Fuller was not yet saying so, but New South Wales was willing to pay for the Clarence River Bridge itself.

In August 1924 the deal to build the railway was done, and it did not include the Clarence River Bridge, which would remain a New South Wales responsibility. Stewart retained hopes for his link from Port Augusta to Hay, continuing to negotiate fruitlessly with South Australia, and one report prematurely headlined the story 'Railway Uniformity: Pacific to Indian Ocean'. More accurately, it observed that, 'The realisation of the uniform gauge connecting Brisbane to Albury now appears to be not far distant. The distance between Sydney and Brisbane will be reduced by 100 miles, and the new line will develop some of the best lands in the Commonwealth.'[36]

The Grafton-Brisbane Railway Bill was debated in the House of Representatives on 24 September. Support came from New South Wales and Queensland members regardless of party, but there was some scepticism from the southern states. Frank Forde, the Labour member from Rockhampton said 'he would not lecture members because he believed that some were more intelligent than himself (Laughter)', then proceeded to do so at some length on the railway's merits.

Attorney General John Latham objected, to which Forde replied that Latham 'took his instructions from the press and so, as a Victorian, therefore would oppose the Bill'. At this point the speaker, former Victorian Premier, William Watts, intervened to remind Forde of parliamentary niceties: "I hope that the honorable member does not use the word "Victorian" as a term of reproach.'[37] More laughter followed and, among general good humour peppered with state rivalries, the Bill went through. In the senate, there was opposition from South Australian and Western Australian senators, but the Bill passed in to law on 9 October 1924 by 16 to six votes.[38] As for Latham, in fact he supported the railway and actually ended up turning the first sod when construction began at Kyogle nearly two years later, where he argued strongly in favour of standardising all Australia's railways and said specifically of this project:

> As a Victorian member in the Commonwealth parliament I am honoured in acting as an Australian Minister in performing an Australian ceremony. This work is a genuinely national enterprise – it is one of the fruits of federation. May it help to promote the prosperity not only of this beautiful and fertile district but also of the whole of Australia.[39]

The ratifying legislation passed through the Commonwealth, Queensland and New South Wales parliaments in the same month. The Queensland Act (No 10, 1924) was assented to on 6 October 1924, the Commonwealth Act (No 54, 1924) on 20 October and New South Wales Act (No 20, 1924) on 28 October 1924. Their substantive provisions were identical, although their preambles differed. The Queensland and Commonwealth Acts' preambles reminded readers that the premiers and Commonwealth had agreed in Melbourne in July 1920 to standardise Australia's railways

33 *The Argus*, 15 April 1924.

34 *Canberra Times*, 7 April 1924.

35 *Australian Dictionary of Biography*, Vol 9, p 11.

36 *The Argus*, 6 August 1924.

37 *The Argus*, 26 September 1924.

38 *The Argus*, 10 October 1924.

39 Latham's speech at Kyogle is quoted in Wilson, *Kyogle-Brisbane Golden Jubilee*, p 14.

on an agreed financial basis. This contradicted the Act's purpose, which stated clearly that only two states had abided by the agreement.

The inclusion of this contradiction in the Act's preamble would appear to be deliberate and, by the rarefied standards of parliamentary draughtsmanship, a bitchy snipe at the states which had refused to come on board. Queenslanders can be direct, and the New South Wales Act was more diplomatic about the self-centred slackers in the south and west of the continent. The Queensland Act also differed in having a clear statement of the wider aims of the project: 'in order to facilitate interstate trade and commerce and to assist in the development and defence of Australia it is desirable to secure a uniform gauge of railway line throughout Australia'.[40]

The Acts provided for the creation of a Uniform Railway Gauge Council, generally known as the Railway Council, comprising the three Commissioners of the Commonwealth, New South Wales and Queensland Railways. This Council was to have 'the entire control of … all the works and … expenditure thereon', including employment of staff, standards of construction and types of rolling stock. The obligation of the Railway Council to report its activities and expenditure regularly to the three governments has meant that more detail survives in the archives about the construction of this railway than about almost any other in the country. (Clause 10). The Railway Council assumed the role the Royal Commissioners had suggested for the Director of railway standardisation. As a council of existing commissioners rather than an independent director appointed by the Commonwealth, it was far less threatening to state rights over their railways than the 1921 proposal for a director.

The funding of the railway was complex and varied from what the premiers had agreed in 1920. The Commonwealth was to provide all funds, both its one fifth of costs as agreed in 1920 and the four-fifths due by the states. New South Wales and Queensland were to reimburse the Commonwealth for their share of the states' four-fifth allocated annually on the basis of state population. What this arrangement meant was that the Commonwealth assumed the payments due by Victoria, South Australia and Western Australia, which these states had been obliged to pay under the 1920 agreement but now refused to pay (Clause 9).[41]

Revenue from the railway's operations was to be collected proportionally by the New South Wales and Queensland Railways, which were also proportionally responsible for working expenses. The Acts were silent as to exactly how the two state railways were to share revenue and expenses, or even whether the Queensland section was to have its own rolling stock or not. These matters were left to the NSWGR and Queensland Railways to sort out among themselves. It became increasingly clear that it would be most efficient if the NSWGR actually operated the trains with its own rolling stock, but Queensland wanted the new railway to offer employment opportunities for its staff.

The formal decision was not made until very late: under the terms of the Queensland Border to South Brisbane Railway Management Act (1930), which went through the Queensland parliament the day before the railway opened, the NSWGR would operate the trains and maintain the track throughout, including on the section owned by Queensland. Ownership of the railway would be by the two states on their own territory. Operating profits were to be allocated first to the Commonwealth to pay interest on its payments made on behalf of the states which had refused to pay their share; second to New South Wales and Queensland to cover interest on their share of capital cost; third to the Commonwealth to cover interest on its one fifth of the capital invested. Any remaining profit after interest was paid was to be divided between the NSWGR and Queensland Railways as they saw fit, presumably on the same basis as they divided operating costs and revenue (Clause 13).[42]

Within two weeks of the Acts being passed, the three commissioners forming the Railway Council had met. Commonwealth Railways Commissioner Norris Bell chaired the Council, whose other members were James Fraser, New South Chief Commissioner of Railways and Tramways, and James Davidson, Queensland Commissioner for Railways. The Council met for two days every two or three months (rarely more often) alternately in Melbourne, Sydney and Brisbane. Its work was important and it corresponded directly with premiers and the Prime Minister. Railway commissioners in the 1920s spent a lot of nights in sleeping cars and did a lot of changing trains from one gauge and to another at dawn in Albury and Wallangarra.

The Chief Accountants of the three railways met in Melbourne from 2 to 4 December 1924 to work out the details of funding, expenditure, stores, employment and generally getting the project moving and their engineers two months

40 Copies of the three Acts, with annotations on the copy of the New South Wales Act to guide the Railway Council, are in SRNSW Series 15668, Item 4. Queensland parliamentary draughtsmen were also far less fond of commas than their counterparts in Sydney and Melbourne.

41 NSW 15 Geo V Act No 20, 28 October 1924, SRNSW Series 15668, Item 4.

42 NSW 15 Geo V Act No 20, 28 October 1924, SRNSW Series 15668, Item 4.

later.[43] The striking thing about the minutes of these meetings is the 'can-do' attitude of the senior railway officers. They wanted no delay, and were totally confident that bringing the different practices of the three railways into line, using the best features of each, was desirable, possible and, so far as this project was concerned, would be done immediately. They listened to each other, compromised, and were quite willing to admit it when they considered their colleagues on other railways had superior methods.[44]

## 4. Building the Uniform Gauge Railway

Once the decision to build the railway had been taken, work began quickly. By March 1925 the first engineers were on the ground, men were being employed and the work was beginning. The first task undertaken was the rebuilding of the section from Grafton to Kyogle, since this would be done by the NSWGR and would not require tenders to be called.

It all happened so quickly that A.E. Morris, in charge of works at Casino, had to write his first report on all the activity on his patch by hand, observing that, 'the typewriter has not yet arrived' but concluding with the request, 'would you kindly endeavour to urge things along as I would like to finalise the first cost as quickly as possible.'[45] Wickham had chosen his subordinates well. There was to be no shirking and no delay with this project. The NSWGR's was able to relay the track and ballast its Grafton to Kyogle line very quickly. The work included the replacement of all timber bridges with steel plate girders on concrete piers of the same design as those on the new railway north of Casino. The 1905 steel truss bridge over the Richmond River just south of Casino was replaced with a new heavier truss. Signalling was replaced on the entire line and new crossing loops opened in anticipation of the additional traffic. The new signal boxes at these loops were to a standard design built of fibro asbestos and the new signalling was miniature electric staff, then the most advanced and secure signalling system used on single track sections on the NSWGR.


*Figure 3: Queensland entrance to Border tunnel*

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43 Minutes of the Meeting of Chief Accountants held at the Office of the Comptroller of Accounts and Audit, Commonwealth Railways, Melbourne, on 2nd, 3rd and 4th December 1924. SRNSW, Series 15668, Item 4.

44 Minutes of the meeting of the Chief Accountants and Chief Engineers held at the office of the Chief Accountant, NSWR, Sydney on the 26th February 1925. SRNSW, Series 15668, Item 4.

45 *Ibid*.

One important element of the proposed rebuilding was sacrificed to contain costs: the planned improvement of the alignment and grades. Thus there remained two sections of 1 in 50 grades facing northbound trains leaving Grafton, near Lawrence Road and Rappville. The result was that, until dieselisation, heavy passenger trains often required assistance from a second locomotive from South Grafton to Lawrence Road, generally an ancient Z12 class 4-4-0. This was precisely the sort of operational and financial problem the NSWGR wanted to avoid on its new railway, but short deviations improving the alignment and grade at these two locations would not be opened until 1995. It was a long while to wait for work planned in 1924.

The engineers in both states quickly prepared estimates for the Railway Council's second meeting in November 1924. The original standards of 16 chain radius curves and 1 in 80 grades were tightened to 12 chain curves and 1 in 66 grades to reduce costs. New South Wales estimated of the cost of construction of its 27 miles and 14 chains from Kyogle to Richmond Gap at £1,128,641 or £41,533 per mile. This section included the 3,806 foot border tunnel. Although planned as a double track tunnel, both to provide ventilation because of its length and in case of future duplication, some £115,182 could be saved by building a single track tunnel, reducing the cost to £1,013,459.The Queensland estimate for its much easier section from South Brisbane to the northern portal of the tunnel was £1,587,504, to which the Council added £60,000 to ease curves and grades.[46] The maps accompanying the Acts show that the railway had been surveyed and its main features designed. The spiral at Cougal where the railway climbs the ever steepening and narrowing valley of Grady's Creek, was already clearly marked on the maps. Once the decision to build the railway had been taken, work began quickly. In the first week of 1925 Queensland Minister for Railways James Larcombe visited Sydney to stitch up the details of the deal.[47] Tenders for construction of the railway were called in June 1925 and closed on 1 September 1925. The Railway Council was disappointed with the tenders and decided instead to contract construction to the state governments for the sections in their own states, with the McPherson range tunnel to be part of the New South Wales contract.

In July 1926 an Amendment Bill passed through Federal Parliament to increase expenditure from £3,500,000 to £4,000,000.[48] By then expenditure had already reached £760,300, of which £437,750 had been spent in New South Wales and £322,550 in Queensland. No fewer than 1,280 men were employed on the project already, 770 in New South Wales and 510 in Queensland. The Grafton to Kyogle railway already had been ballasted throughout and 80 pound rails had replaced the 60 pound rails over half its length.[49]

The country through which the railway was built was rugged and beautiful. From each side of the McPherson Range flowed the headwaters of the Richmond and Logan Rivers. The country was heavily timbered and there was little level ground. Rainfall was exceptionally high and floods were frequent. The temporary roads cut into the bush to provide access to construction sites often degenerated into quagmires after rain, as the rich volcanic soil was very heavy. It was estimated that a year's work was lost on the section along Running Creek leading to the Queensland portal of the McPherson range tunnel.

Construction was an arduous business, especially on the uppermost section of the Queensland side where the railway followed Running Creek and on the New South Sales side north of Wiangaree. The isolation of the most demanding works meant that there was little use of modern machinery, even though estimates were 'based on machinery being used where possible'.[50] Although some steam shovels were used on the bigger cuttings, the very poor roads made getting them to worksites difficult. So, for the most part, horses hauled ploughs or scoops to excavate the cuttings and carried away the fill in tipping drays. Steam engines drove compressors to provide air for pneumatic drills and generators to light the tunnels, so there were some modern touches but, in most respects, this was the last big railway project in Australia undertaken by men living in camps under canvas and with energy supplied by human and animal muscles.

46 Minutes of the Second Meeting of the Railway Council held in Sydney, 26 November 1924. SRNSW, Series 15668, Item 4.

47 *The Argus*, 7 January 1925.

48 *The Argus*, 8 July 1926.

49 *The Argus*, 10 August 1926.

50 Minutes of the Second Meeting of the Railway Council held in Sydney, 26 November 1924. SRNSW, Series 15668, Item 4.

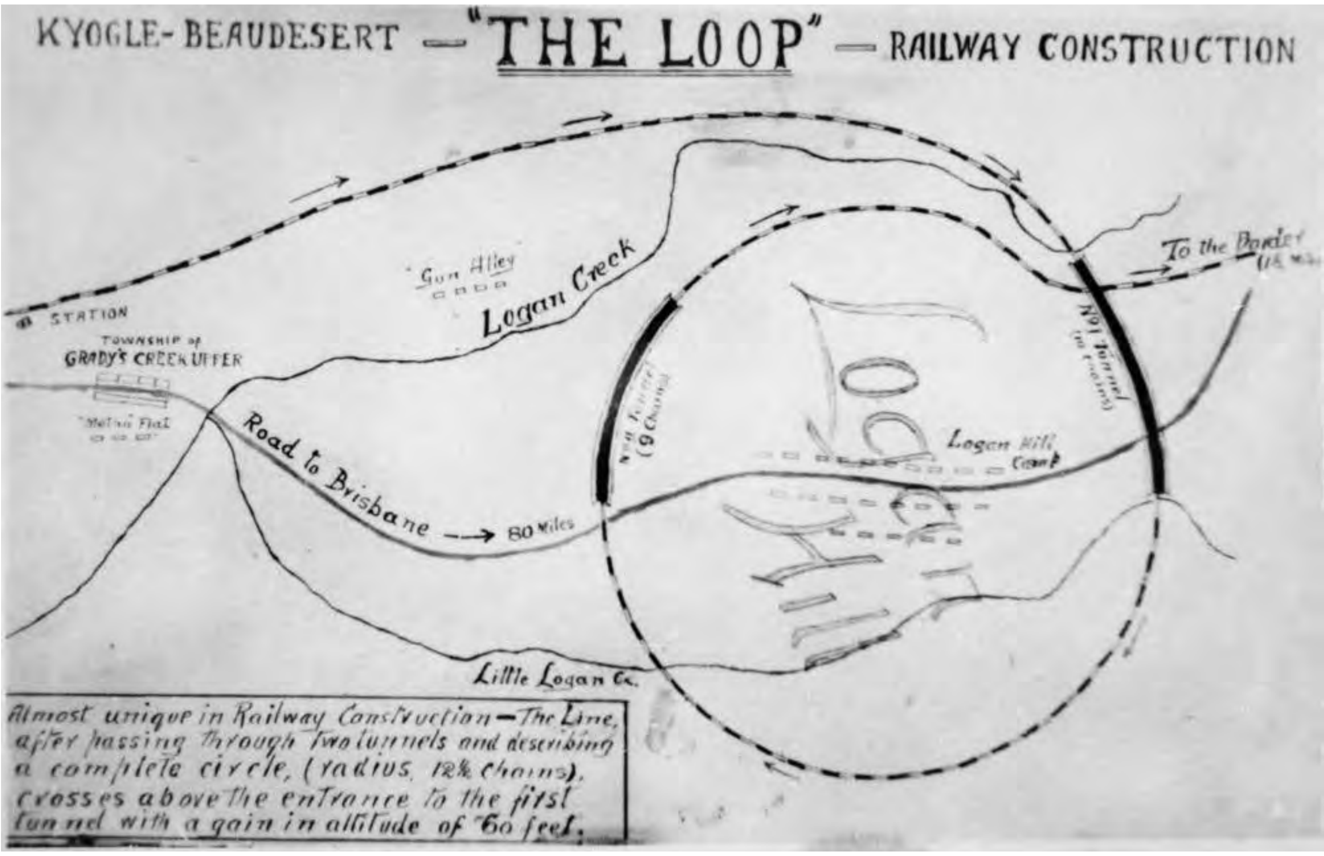


*Figure 4: The Cougal Spiral*

Horse teams brought in most of the supplies on the New South Wales side from the railhead at Kyogle and later Wiangaree. On the Queensland side rail access was easier and equipment was brought to sidings on the shire tramway at Dulbolla (near Rathdowney), where there was a depot for construction materials, and Innisplain (where both the tramway and new railway crossed the Logan River). Beyond Innisplain there were up to fourteen bullock teams working and only one horse team. The Queensland resident engineer, Bashford, in charge of the section from Innisplain to the border tunnel, used bullock teams to bring the steel spans into position on the Queensland section, as truck access was impossible. Bashford just had one steam shovel available although his men did have pneumatic drills powered by a steam compressor. Because transport into the area was so poor, these were fuelled by locally cut firewood rather than coal. Thus, apart from the drills and steam shovel, the Queensland section was constructed entirely by muscle power.[51]

Conditions for workers were as tough as the environment. They lived under canvas in camps set up for them. However, the pay of construction workers was quite good, with most men paid over £11 per fortnight. Even a 16 year-old boy could earn £9 5s a fortnight as a 'nipper', carrying drinking water and boiling the billy for the men.[52] This was at a time when a 'five pound a week man' had some status and was considered well paid. For workers who indulged their vices in moderation (or had none), it was easy to save money working on the railway, even if there was a family to support elsewhere.

This transient society of mostly single young men needed policing, and Cougal briefly had a police station. It was a hazardous posting: one policeman, Laurie Alpin, drowned in a flood in February 1928 while trying to prevent a footbridge from being washed away. Another constable reported having a loaded revolver pointed at him to deter him from being too assiduous in his duties.

51 These details of construction are from Wilson, *Kyogle-Brisbane Golden Jubilee*, pp 15-17, 34-35. Wilson was a boy during construction and knew many men who worked on the railway.

52 Wilson, *Kyogle-Brisbane Golden Jubilee*, pp 21, 44-45.

Although most men in the camps were simply trying to make a good living in hard times, and indeed succeeded in doing so, the camps certainly attracted a criminal element which could readily exploit the sorts of tensions which inevitably develop in a society comprising almost entirely young men with few recreational opportunities.[53] The nicknames of the two most notorious camps, Metho Flat and Gun Alley, both housing workers on the Cougal spiral, spoke volumes about their reputation. Ethnic tension and the scars of war led to disputes among workers, which ultimately involved the Federal Executive of the Returned Sailors and Soldiers Imperial League (RSSIL) and the Railway Council. The issue was the alleged preference of some gangers for employing foreigners, which lead to fisticuffs in Kyogle in July 1928.[54]

This 'fracas' provoked a formal complaint in writing about the situation on the New South Wales side and a similar complaint about employment north of the border by a deputation of the Queensland state RSSIL to the Railway Council at its meeting in Brisbane on 12 July.[55] The Railway Council informed the RSSIL that preference for returned soldiers in employment was indeed its policy, that in fact preference was generally given, and secured the dismissal of the labour agent who allegedly 'did not appear to comply strictly with the instructions' about such preference.[56] On the Queensland side, labour recruitment was less contentious, as from the beginning the Queensland Railways engineer would inform the RSSIL and the Australian Workers Union offices in Brisbane of the numbers of men required on certain dates, and then personally attend the offices of each organisation to select suitable men.[57]

The last piece of heavy construction completed was the Richmond Gap tunnel. This was part of the New South Wales contract, but the cement to line it was supplied from the Queensland Cement Company in Darra and railed to the site direct by Queensland Railways, who billed New South Wales for the carriage. The final job was the conversion of the Queensland section to standard gauge. This was easier, faster and cheaper than might be imagined, as the sleepers and everything else were to standard gauge specifications. Queensland carried out the job, with narrow gauge work trains retreating from the portal of the Richmond Gap tunnel towards South Brisbane, leaving standard gauge track behind them. The ease of conversion and the ability of Queensland Railways to ship construction materials such as bridge girders and cement from all over their network to the worksites during construction had justified the decision to build the railway temporarily to the narrow gauge.

Everything at last was ready for the opening of the direct standard gauge railway from Sydney to Brisbane. Everything, that is, except the Clarence River Bridge.

## 5. The Clarence River Bridge, Grafton

The Clarence River Bridge at Grafton was a separate project from the Uniform Gauge Railway and was not part of the partly Commonwealth-funded interstate railway. New South Wales premier George Fuller had attempted but failed to make the bridge part of the project at negotiations with Prime Minister Bruce in Sydney in April 1925. Nonetheless, it formed a crucial part of the new through interstate railway and was built at the same time and the Railway Council took a lively interest in its progress. In fact, the bridge was not completed until nearly two years after the railway.

Following the completion of the North Coast railway to South Grafton in 1924, coincidentally the same year that the Acts providing for the link to Brisbane were passed, the only gap on the coastal route was across the Clarence River between South Grafton and Grafton. The NSWGR had worked out its own strategy to bridge the gap without a bridge, temporarily at least. The temporary solution was a train ferry, and thus began the eight year history of the NSWGR's unique, even romantic maritime operations on the Clarence River. The train ferries were adequate for rail traffic through to Lismore and Casino, but not for the new interstate link. However, the bridge was not part of the Grafton-South Brisbane Uniform Gauge Railway project. New South Wales naturally enough had wanted it to be, in order to attract Commonwealth and Queensland funding, but two decades earlier it already had decided, with the support of the Parliamentary Standing Committee on Public Works, in principle to build the bridge as part of its North Coast line from Maitland to Murwillumbah.

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53 *Ibid*, pp 28-31.

54 Dieden, General Secretary RSSIL to Simms, Secretary Railway Council, Melbourne, 23 July 1928. SRNSW, Series 15668, Item 4.

55 Minutes of Railway Council Meeting, Brisbane, 11-12 July 1928. SRNSW, Series 15668, Item 4.

56 Morris, Secretary NSWGR, to Simms, Secretary Railway Council, 17 October 1928. Minutes of Railway Council Meetings in SRNSW, Series 15668, Item 4.

57 Chairman's visit to Brisbane. 29 May 1925. Confidential. SRNSW, Series 15668, Item 4.

New South Wales was trapped by its previous commitment to build the bridge into spending the half million or so pounds needed itself, recognised its situation, and so agreed to exclusion of the bridge from the project. At its very first meeting, the Railway Council's Chairman Norris Bell wrote to Prime Minister Stanley Melbourne Bruce, asking him to write to New South Wales Premier George Fuller 'urging the early completion of the Clarence River Bridge', so that it would be finished at the same time as the railway through to South Brisbane.[58]

Fuller replied that he had asked the NSWGR to put the bridge on its estimates for work to begin in 1926, and informed the Council that the bridge and the railway connecting Grafton and South Grafton stations would cost £560,459, with the bridge alone costing £350,375. The railway through Grafton was quite expensive, as it would be elevated on a long embankment, with bridges over Grafton's streets, and would also involve considerable urban resumptions. Because it was through the heart of Grafton, its bridges over the city's streets had to have aesthetic merit as well, and indeed did so. The bridge itself was to be a steel truss structure of four 250 foot spans, with a bascule opening span of 60 feet. An upper deck would carry a reinforced concrete roadway 22 feet 6 inches wide at a cost of £81,475, to be provided by the Public Works Department, in recognition of that fact that this expenditure would obviate the need to construct a separate road bridge to replace the existing busy vehicular ferry.[59] That was all very well, but the Railway Council wanted a faster start and Fraser agreed to meet Fuller 'urging this work to be commenced without delay and without waiting for the usual Parliamentary Estimates to be passed towards the close of 1925.'[60]

In undertaking the construction of the Clarence River Bridge, New South Wales added yet another project to its enormous investment in railways during the 1920s. In 1925 the state was in the process of electrifying Sydney's suburban railways (including resignalling and widening of clearances to accommodate wider new suburban carriages); building the Sydney Harbour Bridge and the city underground railway; and constructing new interstate links to Broken Hill and Brisbane. In addition hundreds of passenger carriages, close to a thousand new suburban carriages, thousands of goods wagons, 75 heavy express passenger locomotives (C36 class) and 25 of the heaviest and most technically advanced goods locomotives yet built in Australia (D57 class) were on order. It was a massive expression of confidence in the NSWGR's ability to grow its traffic, handle it efficiently, and so generate the profits needed to repay the interest on the more than £30 million which were borrowed to pay for all this.

*Figure 5: Trial assembly of the bascule span at Clyde Engineering in 1928.*

58 Minutes of the Second Meeting of the Railway Council held in Sydney, 26 November 1924. SRNSW, Series 15668, Item 4.

59 Fuller to Bell, 28 April 1925, quoted in Minutes of the Fifth Meeting of the Railway Council held in Sydney, 10-12 September 1924. SRNSW, Series 15668, Item 4.

60 Minute 64. Minutes of the Fifth Meeting of the Railway Council held in Sydney, 10-12 September 1924. SRNSW, Series 15668, Item 4.

The Clarence River Bridge was and remains the third greatest railway bridge in New South Wales, after its exact contemporary, the Sydney Harbour Bridge (1932), and the Hawkesbury River Bridge (1889, replaced 1946). It is a series of Pratt trusses as modified and standardised for use on the NSWGR by Public Works Department engineer James Waller Roberts. When the decision to construct the North Coast line from Maitland to South Grafton was taken in 1906, the intention was that 'the track will be of first class character, capable of carrying the heaviest traffic and at the maximum speed.' This included such details as track geometry and bridges.

Whatever the continuing limitations on speed which the railway's track geometry imposed, Roberts' truss bridges have proved to be an enduring and important design. No fewer than 22 of these bridges were opened on the North Coast line between 1911 and 1924. The engineers who implemented Roberts' bridge designs were significant figures. William Hutchinson, the Engineer in Chief for Railway and Tramway Construction and future designer of the Kyogle-Richmond Gap railway including the Cougal spiral, had overall control of the entire North Coast railway project. His successor, F.E. Wickham, later a critical figure in building the Uniform Gauge Railway, was resident engineer for the first stage of construction between Maitland and Taree. J.J.C. Bradfield supervised the drawings for the bridges and the railway as a whole, his last project before he devoted his life to the Sydney city railway and Harbour Bridge.[61]

The truss spans of the Clarence River Bridge were generally based on Roberts' earlier designs for North Coast bridges, although it also included a double-deck opening bascule span. So far as can be ascertained, this is the only bascule span on a heavy railway bridge with a road on the upper deck in the world. While the principle of the span is based on the 1901 US patent of Theodore Rall, it was designed and built by the NSWGR's own engineers. The Rall patent involves moving rollers and is therefore suitable for a double deck bridge. Its most significant previous use was in the Broadway Bridge across the Willamette River in Portland, Oregon, opened in 1913.

The Broadway Bridge was a truss bridge and so essentially it was on two levels – the top and bottom of the truss. Therefore it needed the moving rollers to enable the truss span to open. The Clarence River Bridge took the design one stage further and to a new level of complexity by including a road laid across the top of the trusses. Apparently the only other double deck opening rail and road bridges in the world are in Chicago. These are basically road bridges, whereas the Clarence River Bridge is basically a railway bridge. The railway in the case of the Chicago bridges is a lightly engineered elevated suburban line and is above, not below, the road deck. In fact, the Chicago elevated is only slightly heavier in construction than a tram line. Therefore, the engineering challenges presented by the Chicago bridges were far more modest than those presented by the bridge at Grafton.

*Figure 6: Grafton road/rail bridge opening. Sir Isaac Isaacs, Governor-General, inspecting Northern Rivers Lancers 15th Light Horse prior to the parade for the opening of the bridge (photo from NSW RailCorp archive.*

61 *Ibid*, pp 96-100.

Only two tenders were received for the Clarence River Bridge: one from Dorman Long and Company, then building the Sydney Harbour Bridge, for £484,190; the other from John Grant and Sons for £499,250. Tenders closed on 15 June 1926, a week before Federal Attorney General John Latham turned the first sod of the new railway at Kyogle.[62] The New South Wales government rejected both tenders as too high and decided to undertake the job itself.[63] The first rivet in the caissons of the bridge was driven on 11 June 1928. It was to cost £529,000, of which £83,650 was for the roadway. Clyde Engineering secured the contracts both for the caissons and the superstructure, to cost £22,000 and £144,500 respectively. Clyde had agreed to deliver all the steelwork by July 1930 and its opening was then expected some time in 1931.[64]

The Clarence River Bridge was officially opened by Governor General Sir Isaac Isaacs on Tuesday 19 July 1932. The choice of Isaacs was politic. He was the first Australian governor general, so not a British aristocrat, which reassured those of left-wing leanings; but he was the King's representative rather than a politician, which appealed to the more conservative. So there was none of the drama which had accompanied Premier J.T. Lang's opening of the Sydney Harbour Bridge two months before. 'Deafening cheers' followed Isaacs' cutting of the ribbon, aeroplanes flew overhead, Grafton was bedecked with flowers, and crowds surged to walk over the bridge's roadway.[65] Isaacs, with his national perspective, spoke expansively of the achievement, emphasising the bridge's national and even global significance rather than the local importance which was the traditional stock-in-trade of speeches at railway openings. At the same time, he warned that the job was far from done:

> This bridge is of national, and even Imperial, significance, because it constitutes an essential link in the great chain of defence of this Dominion and of Australian and interstate trade and commerce and intercourse. That chain has now been established from Brisbane to Albury, and also along the Commonwealth transcontinental line of railway. Much remains to be done, however, before the chain is complete.[66]

Isaacs' emphasis on defence was prescient for, exactly a decade after his speech, the bridge was indeed crucial for transport to the front line of the Pacific War, as coastal shipping suffered enormous losses from Japanese torpedoes.

## 6. Opening Day and Early Traffic on the New Railway

The opening had been scheduled for 1 August 1930, but this was a railway through rainforest, and rainforests mean rain. Floods delayed the opening for six weeks until Saturday 27 September 1930.[67] The weather was perfect, with not a cloud in the firmament, the exact opposite of the mud and drizzle at the turning of the first sod four years earlier. The 'shouting and the tumult' with which the 'wildly excited' crowd at Kyogle greeted the first train was just the beginning. People packed the little station, which was decorated with flags and bunting, and as many as could fit climbed onto its roof for a better view.[68]

*Figure 7: Kyogle opening 27 September 1930.*

Passengers on the train included an official party led by Frank

62 *The Argus*, 22 June 1926.

63 The story of the refused tenders is in the reporting of debate in the Federal Parliament in *The Argus*, 8 July 1926

64 *Canberra Times*, 18 February 1929.

65 *Canberra Times*, 20 July 1932.

66 *The Argus*, 20 July 1932.

67 *Canberra Times*, 11 July 1930.

68 The crowds on the roof can be seen in State Library of Queensland Image No 3506. At Kyogle Station when the first train to Brisbane was about to leave.

Forde, a long-time advocate of the railway and long-serving Federal Labor Member for Capricornia (1922 to 1946) and then Acting Minister for Customs. With him were the Country Party leader, Grafton doctor Earle Page, and R.T. Ball, Commonwealth Railways Commissioner. Both Forde and Page were briefly future prime ministers. The New South Wales contingent included the Chief Commissioner for Railways, W.J. Cleary, and the now retired Engineer-in-Chief for Railway Construction F.E. Wickham, who had done so much towards building the railway and often sat on the Railway Council.[69]

Frank Forde rode the locomotive into South Brisbane station, where the train was greeted by a band and the wife of Queensland premier Arthur Moore cut a ribbon. Brisbane Lord Mayor William Jolly hosted a reception in the new City Hall that night, and ten days later (on Monday 5 October) played host again for a day-long visit by about a thousand children from northern New South Wales. They took a special train into Brisbane for the day, where they were entertained with a tram ride around the city and lunch in Musgrave Park.[70] The children's special showed how real and convenient the link now was between Brisbane and the New South Wales north coast. Regular services began on 28 September.

The new railway did not disrupt traditional patterns of goods movement. Byron Bay's butter continued to go by ship to Sydney for transhipment and export, rather than be railed to Brisbane for export. Brisbane did not replace Sydney as the centre of trade for New South Wales north coast towns. The old fears that a railway from the New South Wales north coast to Brisbane would weaken Sydney's mercantile position and possibly ruin the NCSNCo were not realised. In fact, there was no access at all from the new railway to wharves in Brisbane, and would not be for many decades until the opening of the Dutton Park to Fisherman's Islands standard gauge line in May 1997. Therefore, goods traffic from the Casino and Kyogle districts never was diverted to Brisbane, but continued to be shipped from Lismore, Grafton or Byron Bay. Coastal shipping from these ports declined rapidly after 1941 and ended completely in 1954, but the traffic thereafter overwhelmingly went by rail to Sydney, not Brisbane.

In the 1930s most freight between Sydney and Brisbane continued to go by sea. In 1925 some 166,000 tons of freight were transhipped at Wallangarra, which sounds a lot until it is calculated at 227 tons per day each way – a modest load for one train on the NSWGR, and just enough to justify two trains on Queensland Railways' steep grade to Toowoomba. 40,000 tons of this was fruit from Queensland, for which a daily fruit express ran from Brisbane to Wallangarra.[71] The higher productivity and easier grades of the new railway meant that this traffic could be accommodated in a thrice-weekly fruit express from Clapham Yard in Brisbane to Grafton, where its vans were transferred on the *Swallow* for forwarding to Sydney. Other goods services did not commence until late in 1931, and were confined to one conditional train per day, which meant that it did not run unless sufficient traffic were on offer.[72]

Thus, most of the traffic on the new railway was passengers and mail. In 1925 110,000 interstate passengers had changed trains at Wallangarra, an average of 150 each way per day.[73] The NSWGR provided two very stylish trains of its latest carriages for the run between Grafton and South Brisbane. The new *Brisbane Limited Express* left Sydney every day of the week at 7.30pm and, after breakfast at Coffs Harbour, arrived at South Grafton the next morning at 9.43. The NSWGR chartered the river steamer *The Clarence* from Charles Pullen of Cowper to carry the *Limited*'s passengers across the river, while the train's vans crossed on the *Swallow*.[74] The new train, all gleaming black paint and varnished cedar, waited at the special platform built adjacent to Grafton railway wharf, leaving at 10.57am. Lunch was served on board during the exceptionally scenic trip to Brisbane, where arrival was scheduled for 5.15pm.

69 A contemporary account of the event is reprinted in Wilson, *Kyogle-Brisbane Golden Jubilee*, pp 46-47. Musgrave Park is now South Brisbane Park, and is in easy walking distance of South Brisbane station

70 *Brisbane Mail*, 25 September 1930, in Wilson, *Kyogle-Brisbane Golden Jubilee*, p 50.

71 *The Argus*, 8 July 1926.

72 Dunn, *The Tweed Railway*, p 167.

73 *The Argus*, 8 July 1926.

74 Stuart Lee, *Riverboats of the Clarence*, Yamba, Port of Yamba Historical Society, 2003, p 149.

passengers over the highest railway summit in Australia. After the Grafton Bridge was opened, the ferry ride across the Clarence was eliminated, cutting about an hour from the run. Passengers could then travel between Sydney and Brisbane without any change of train. From 1932 the *Brisbane Limited* left Sydney at 7.30pm and arrived at South Brisbane at 4pm.[75] There was also a twice daily local service between Casino and Border Loop, locally known as 'the squirt' until the war years and thereafter as the 'mountain goat'. Initially a rail motor, from 1932 it was a mixed train taking local goods traffic, normally worked by a Z13 class tank engine of no great power, reflecting its light goods loading.[76]

The Grafton to South Brisbane railway was the first, and for over a decade, the only tangible result of the 1921 Royal Commission. The second would be the complementary extensions of Commonwealth Railways' Trans-Australia Railway from Port Augusta to Port Pirie and of South Australian Railways' broad gauge metals from Adelaide to Port Pirie, completed in 1937. This replaced two break of gauge stations (Terowie and Port Augusta) with one (Port Pirie). It also eliminated the circuitous and steeply graded narrow gauge section between Terowie and Port Augusta. Like the Grafton-South Brisbane railway, these extensions created a direct route parallel to the coast where the previous route had evolved from an inland higher-altitude connection between two older port-to-hinterland railways. Thereafter, although there were many plans and much debate, nothing would be achieved in standardising Australia's railway gauges until the late 1950s.

The Kyogle-South Brisbane section's brilliant prospects as a developmental railway expressed in such glowing terms in the 1916 Royal Commission Report were not realised, largely due to improved road transport and self-imposed legislative restrictions in Queensland. In fact, the era of the developmental railway in Australia effectively was over by 1920 and most of those built during the 1920s were dismal failures, characterised by depressing balance sheets, infrequent and poorly patronised services, and consequently short histories.

As a developmental railway, it came too late. Trucks and good roads could serve the needs of small farmers better than railways from the 1920s. As a result by the 1930s the Country Party was more interested in pushing for rural road improvements than new railways to serve its constituents. The Kyogle-South Brisbane railway effectively closed as a developmental railway when eighty year-old tank engine 1307 worked the last 'mountain goat' back down the hill from Border Loop to Kyogle in 1957, although goods traffic, especially timber, would continue to be shipped to Sydney from small stations like Kyogle and Wiangaree into the early 1980s.

As a main line, however, its history has been more positive and the Uniform Gauge Railway certainly achieved two of its three aims. Its contribution to national defence between 1941 and 1945 was enormous, so it met the military aims which had been so important a motive for the Commonwealth to fund its construction. It also has succeeded brilliantly as an intercapital link, even if it was never quite the high-speed 'express line' of its planners. In its early days passengers dominated its traffic, but since the war freight traffic has developed on a scale and in ways inconceivable in the 1920s.

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75 NSWGR Country Timetable, 20 November 1932.

76 *Ibid*; Dunn, *The Tweed Railway*, pp 167-168.

# HERITAGE ASSESSMENT

## 1. BASIC DATA

**Item Name**: Grafton to Brisbane Standard Gauge Railway including the bridge over the Clarence River at Grafton

**Other/Former Names:** Nil

**Location (grid reference if possible):** see location map

**Suburb/Nearest Town:** Major towns on the route are Grafton, Casino, Kyogle, Beaudesert and Brisbane

**State:** New South Wales and Queensland

**Local Govt. Area:** Various

**Owner**: Rail Corporation NSW (with long term lease to ARTC), QR Limited

**Current Use:** Railways, freight and passenger

**Former Use (if any):** Nil

**Designer:** NSW Railway and Tramway Construction Branch (NSW Department of Public Works to 1917, transferred to Railway and Tramway Department by Act of Parliament on 1/1/1917): J.W. Roberts, Bridge Designer (Clarence River and other truss bridges on route); William Hutchison permanent way works, including Cougal Spiral.

**Maker/Builder:** Governments of NSW and Queensland using their own workforces; Clarence River bridge steelwork fabricated by Clyde Engineering but erected by NSW Government workforce.

**Year Started: 1926** **Year Completed:** 1932

**Physical Description:** A single track railway with passing loops, including bridges and other infrastructure, connecting South Grafton to South Brisbane.

**Physical Condition:** Good, except bascule mechanism has been removed from bridge and misplaced.

**Modifications and Dates:** Bridge closed to river traffic in 1970s. Signalling and other equipment updated over time.

**Historical Notes:** (see separate details)

**Heritage Listings** (information for all listings): There are extensive listings, particularly in NSW: all of them relating to rail infrastructure, but not anciliary buildings, are reproduced in Appendix B.

## 2. ASSESSMENT OF SIGNIFICANCE

**Historical Phase:** The railway is significant historically at a NATIONAL level for being the first collaboration bewteen the Commonwealth and State governments aimed at achieving standardisation of railway gauges.

**Historical Individuals or Association:** Engineers — James Waller Roberts (NSW Dept of Public Works, principal bridge designer), William Hutchinson, Engineer in Chief for Railway and Tramway Construction (bridge construction and designer of Cougal spiral), F.E. Wickham and J.J.C. Bradfield (before turning his attention solely to the Sydney Harbour Bridge. Important politicians — William Hughes, who pushed its construction for defence needs while Prime Minster and, after his losing office, Earle (Grafton Christmas) Page of the subsequent Stanley–Page government.

**Creative or Technical Achievement:** The Cougal spiral (designed by William Hutchison) was the first in Australia; the Clarence River bridge (designed by J.W. Roberts) used a further development of a lifting span type developed by Rall in the USA and previously used on smaller and more lightly loaded bridges in Chicago.

**Research Potential:** Offers research potential for both the social and technical issues connected with its construction.

**Social:** Linked Sydney and Brisbane by standard gauge railway, significantly reducing travel time, changing freight movement patterns (particularly coastal shipping) and marking an important phase in interstate and Commonwealth-State cooperation. In most respects, it was the last major railway project in Australia undertaken by men living in camps under canvas and with energy supplied by human and animal muscles.

An imperative for the Commonwealth in nationalising this project was born out of defence issues analysed in the 1921 Royal Commission after the 1st World War. Its ambitions were firmly realised, as "Its (the railway's) contribution to national defence between 1941 and 1945 was enormous".

**Rarity:** The Clarence River bridge is the only double deck bascule opening span in Australia and the largest in the world.

**Representativeness:** Representative of the culmination of rivetted steel truss bridge design technology.

**Integrity/Intactness:** Full length of railway intact and in use as the only Sydney–Brisbane link now operating. Bridge largely intact and in use except that important parts of the opening mechanism have been removed and mislaid. The bridge was designed for two rail tracks, but only one was ever laid and the space for the second track in now used for pipelines.

**References:** (see history)

**Statement of Significance:** The Grafton to Brisbane railway line is significant at a national level for forming the first standard gauge railway link between state capitals in Australia. Its construction was the first significant outcome of political efforts to unite the Australian colonies by standard gauge rail links; unprecedented cooperation, including parallel legislation, showed the way for subsequent endeavours.

The double deck rail/road bridge over the Clarence River at Grafton is significant at a national and world level for its technical achievement in the design of the opening span. Although using a mechanism first developed in the USA for truss bascules, it further developed it to cater for two decks with heavy loading.

The railway's contribution to national defence between 1941 and 1945 was of high significance.

**Assessed Significance** (whether National, State or Local): National.

**Image(s) with caption(s):** (also see front cover, history and appendices)

## Historical photos – the railway

*Approaching Border Loop on down (i.e. north-bound) in 1937 (photo, Cardew collection).*

*Rail motor at Border Loop, September 1930 (photo Cyril Singleton collection)*

*The Brisbane Limited crosses Pound Street viaduct Grafton, September 1932 (photo Clarence River Historical Society)*

*The Brisbane Express on the Clarence River bridge, 1948.*

*J.W. Roberts designed other steel trusses on the line such as this one at Camden Haven River with timber approach spans.*

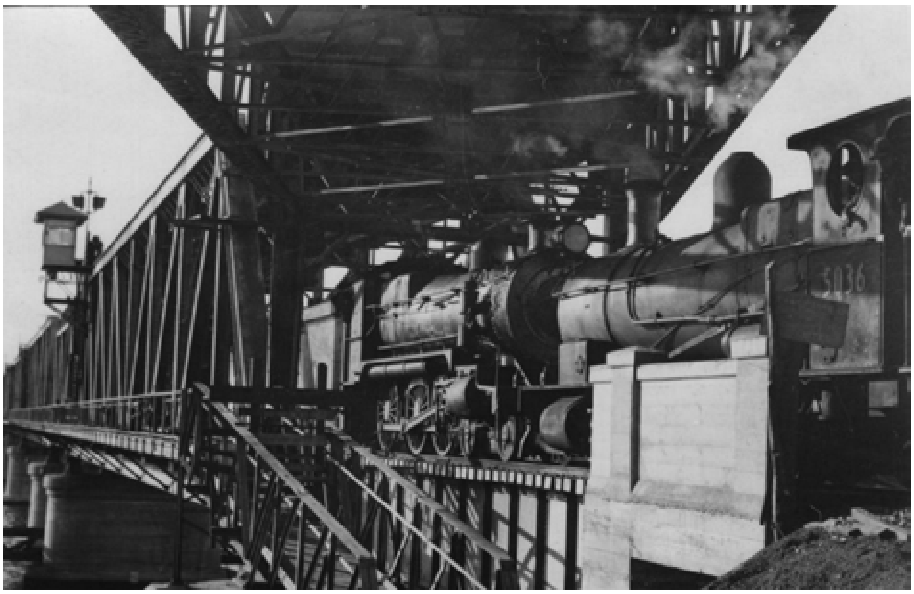
**Historical photos - Clarence River Bridge**

*A further photo of the trial erection of the bascule span at the Clyde Engineering works in Sydney.*

*Final stage of the erection of the bascule span by NSW government employees.*

*Onshore facilities for the bridge erection.*

*Some of the extensive timber temporary works required for the bridge erection.*



*Load testing of the bridge prior to its opening.*

*A RAN Corvette passes through the opened bridge, probably in the 1940s. The last known opening of the bridge was for another naval vessel in the 1970s, but details cannot be confirmed.*

**Modern photos - the railway**

*The Indian Pacific and an XPT pass at Border loop in 1995 (photo, McElroy).*

*Part of the Cougal Spiral can just be seen in this photo. Plant growth now prevents ready observation of this part of the work (photo Robert Lee, 2009).*

## Modern photos - the Clarence River bridge

*Modern photo of the Clarence River bridge taken from a promotional publication.*

*A special train hauled by Locomotive 3801 crosses the bridge in October 2005. The bridge was designed for two tracks, but the second track space is used for water mains (photo Greg Mashiah).*

*The concrete viaduct approaches to the bridge have high significance in their own right (photo Robert Lee, 2009).*

## Interpretation Strategy

Strategy for interpretation of the Engineering Heritage Works is laid out in EHA's "Guide to the Engineering Heritage Recognition Program" (November 2008).

In an overall sense, interpretation will be by: marking the works with an appropriate level of Heritage Marker; a public ceremony to unveil that Marker; and an interpretation panel which summarises the heritage and significant features of the works for the public.

It is proposed, in fact, to prepare interpretation panels at two locations. The first and most immediate requirement is for an interpretation panel at Grafton adjacent to the Clarence River Bridge.

This Interpretation Plan deals only with the interpretation panel proposed for the Grafton site (Another panel is also proposed for the 'Cougal Spiral' lookout, also as part of this HR program, but will be addressed later.)

This Plan provides a summary of the proposal for design, content, location, manufacture and funding of the proposed Grafton panel.

## Structure of Interpretation Panel for Grafton

In accordance with the latest international designs, the panel will be a self-standing sign mounted at waist height, inclined at a 30 - 40 degree angle from the horizontal to facilitate viewing by a person standing facing the panel.

The size of the panel itself will be approx. w:1200 mm x d:500 mm.

The panel material could appropriately be one of a number of suitable materials that meets high standards of corrosion and vandal resistance.

The panel surface coating containing the image could also be provided by a number of modern interpretive products now marketed for this purpose; including vitreous enamel (on steel surface), or plasticised surface-coatings. It must meet high standards of image definition, colour-fastness and scratch resistance.

The panel will be mounted on a solid and strong stand that deters/ resists attack from vandals, but on the other hand provides a pleasing and clean appearance.

A 'standard' panel currently used by the Parks Service of the USA is pictured.

*USS Constitution interpretation panel, (USA Parks Service, Boston USA)*

## Design Process for the Panel Content

The basic panel content will be proposed and an initial laid out by EHA(N). Both the consultant historian, Dr Robert Lee andd EHA(N)'s partner and sponsor of the heritage recognition award, The ARTC will be consulted in preparing the content.

When a satisfactory design content has been achieved, it will be submitted for the approval of the EHA HR Cttee., and ARTC. Following approval of the draft design and content, it will be submitted to the EA's Marketing Manager in the Canberra office, who will finalise the graphical content and prepare an .eps (vector graphics) file required by the surface-coating manufacturer.

## Content of the Interpretation

In accordance with good interpretation practice (see Appendix D of the Guide) the content of the panel will be divided into three themes for ease of understanding by the public. A summary of the proposed content is provided below.

TITLE

The title of the interpretation is proposed to be "The Grafton to Brisbane National Railway Link". This title, while not officially acknowledged during the history of the railway, has been chosen to reflect the physicality of the section submitted for nomination as a heritage works, but also to reflect the several 'national' qualities for which the railway link is being recognised (see heritage assessment section). It also tries to avoid technical jargon in attracting the public's attention to the issues being presented.

LAYOUT

In accordance with good interpretation practice (see Appendix D of the Guide) the content of the panel will be divided into three themes for ease of understanding by the public.

PRIMARY THEME (HISTORICAL)

A body of text will be derived from the nomination document to summarise the railway link itself. It will briefly discuss each of: the route, the purpose of the railway, the major engineering features and its operational success.

SECONDARY THEME (ENGINEERING)

The Clarence River Bridge of 1932 is a major component of the proposed heritage works. As this panel will be mounted in view of the bridge, the secondary theme will be the bridge itself. Topics to be briefly addressed will be: the role of the bridge as the final link in completing the railway; significant engineering features of the bridge (derived from Statement of Significance) and the bridge as an icon for the community.

TERTIARY THEME (SOCIAL/PERSONAL)

It is always good to add a personal theme to a story addressed to the public. In the case of the building of the bridge, it is proposed to introduce the principal bridge designer, J. W. Roberts and his achievements. If possible, credits to the design and building teams may also be added.

GRAPHICS

*Map*

It is proposed to include a map (possibly historical) showing the route of the Railway Link to illustrate the primary theme. This could be artistically added as a background to the panel.

*Images*

Ideally a diagram or photo(s) of significant aspect(s) of the bridge can be selected to illustrate the secondary theme. The historical research has uncovered many possible images for this theme.

*Portraits*

The historical research has uncovered a suitable photo of the bridge designer to add a personal touch to the tertiary theme. It is a family photo and permission will need to be obtained. In addition, several photos have come to light of the opening ceremony of the railway at which Governor-General Sir Isaac Isaacs officiated.

## Location of the Interpretation Panel and Heritage Marker

The Panel will be located in close proximity to the Clarence River Bridge at Grafton. Good interpretation policy suggests that the sign be placed at a view point for the heritage works; preferably allowing readers of the interpretation to be able to see the item, or the detail being described by looking up.

The HR Guide suggests that the Heritage Marker is, preferably, to be placed on the works, out of reach of damage. It should also be visible and as close as possible to the Panel. If this is not possible, then an image of the Heritage Marker can be added to the interpretation content.

An initial study of the possibilities for placement of the Heritage Marker and the Panel has already been carried out, and a suggested area for location is shown in the photos below.


*Proposed site under Grafton Bridge for HR Ceremony and marker/Panel*

*Marker proposed to be located on pier marked, with panel opposite on left.*


## Manufacture

Quotations for the Panel will be called from three manufacturers whom are known to have produced signs of the appropriate quality. A preferred tenderer will be selected from the responses on the basis of price, quality, service and estimate of the cost for replacement of damaged panel surface.

## Funding

An estimate for the cost of the Interpretation Panel at Grafton is $2,000 – $2,500.

EHA(N) will provide volunteer and in-house design resources for the above processes and actions in order to reduce this cost to a minimum (of mainly manufacturing costs).

In his letter of acceptance of the invitation issued to the ARTC to support the HR event (see attached), CEO David Marchant agreed to "…contribute towards the cost of the Interpretation Panels" in accordance with EHA's HR Guide.

## APPENDIX A

**Letter of approval from Australian Rail Track Corporation**

AUSTRALIAN RAIL TRACK CORPORATION LTD

**Ref: 15/175/63-08/13028**

RECEIVED
12 DEC 2008

8 December 2008

Mr R. Caldwell
Chairman
Engineering Heritage Australia (Newcastle)
PO Box 208
THE JUNCTION NSW 2291

Dear Mr Caldwell

**Engineering Heritage Recognition of the**
**NSW – Queensland Standard Gauge Interstate Railway**

Thank you for your letter of 17 November 2008 advising that the Newcastle group intends to nominate the Grafton to Brisbane railway for an award under Engineers Australia's Engineering Heritage Program.

ARTC is pleased to support this and approves of the proposed nomination being submitted. I understand you have sought similar endorsement from the Queensland rail authorities for that part of the railway north of the NSW/Queensland border. I also understand the Newcastle Division will undertake research necessary for the nomination, and will meet much of the costs associated with placing heritage plaques on railway structures included in this project. As set out in the guidelines for the program, ARTC will be pleased to contribute towards the cost of the Interpretation Panels.

As the nomination progresses please liaise with ARTC's Heritage Officer, Harley Dreghorn, (02 8259 0712) who will advise you on arrangements for affixing heritage plaques, how to gain access to the railway corridor to do this, and the location of the Interpretation Panels.

Yours sincerely

David Marchant

**David Marchant**
**Chief Executive Officer.**

AUSTRALIAN RAIL TRACK CORPORATION LTD ACN: 081 455 754 / ABN: 75 081 455 754
Off Sir Donald Bradman Drive, Passenger Rail Terminal Rd, Mile End SA 5031; PO Box 10343, Gouger St, Adelaide SA 5000
Tel: (08) 8217 4366 Fax: (08) 8217 4578 Website: www.artc.com.au

## APPENDIX B

**Papers on the design and construction of the Clarence River bridge by J.W. Roberts (Transactions of Institution of Engineers Australia, volume 13, 1932, pp. 369 to 381 and 405 to 414.)**

# TRANSACTIONS OF THE INSTITUTION

# The Clarence River Bridge.

## PART I.—DESIGN.

By James Waller Roberts, B.E.
*Associate Member.**

*Summary.*—The paper, which is divided into two sections, deals in Part I. with the history, preliminary design and final design of a combined railway and vehicular bridge over the Clarence River at Grafton, New South Wales.

Part II. deals with the construction of the double-deck bridge, consisting of five fixed spans of through Pratt truss type and a bascule span. The railway is carried on the lower level and the roadway on the upper level of the bridge.

### Historical.

The Act authorizing the construction of the Grafton to South Grafton railway received vice-regal assent on 21st December, 1915. It was based on the report of the Public Works Committee, dated 6th June, 1913, and provided for a bridge over the Clarence River to carry a double line of railway and a footway and to have a movable span with a 70 ft. clear channel for the passage of vessels. The route recommended by the committee junctioned with the Grafton—Casino line about three-quarters of a mile from Grafton station and, crossing the river at Wilson's Hill, linked up in the South Grafton yard with the line from Glenreagh to South Grafton, then just completed, (See Fig. 1.)

The estimate for the bridge was based on a tentative design prepared, with several others, by the Railway and Tramway Construction Branch of the Public Works Department of New South Wales, in 1910, at the request of the Chief Railway Commissioner. It covered six fixed river spans, 200 ft. centre to centre of bearings, through Pratt truss type, and a 70 ft. plate girder hinged bascule span.

A series of trial bores, seventeen in all, at intervals of 100 ft. had been taken in 1910, practically on the above route across the river. Except at the southern bank, these indicated an alluvial deposit of silt, sand and shingle and a little clay overlying a sound sandstone rock at depths varying from 26 ft. to 76 ft. below mean high water. Boulders of basaltic character were occasionally encountered. Grafton itself is built on a deposit of this nature and it was found necessary in constructing piers to carry road and railway structures through the city to provide ample piling in the foundations.

The underlying beds are of sandstones, shales and conglomerates constituting the Trias—Jura—Clarence series asserted by geologists to be probably 4,000 ft. thick. The sandstone closely resembles the Hawkesbury type but has been deposited at a more recent geological period. The southern bank, which is still suffering erosion, retains

*This paper, No. 419, originated in the Sydney Division of The Institution.

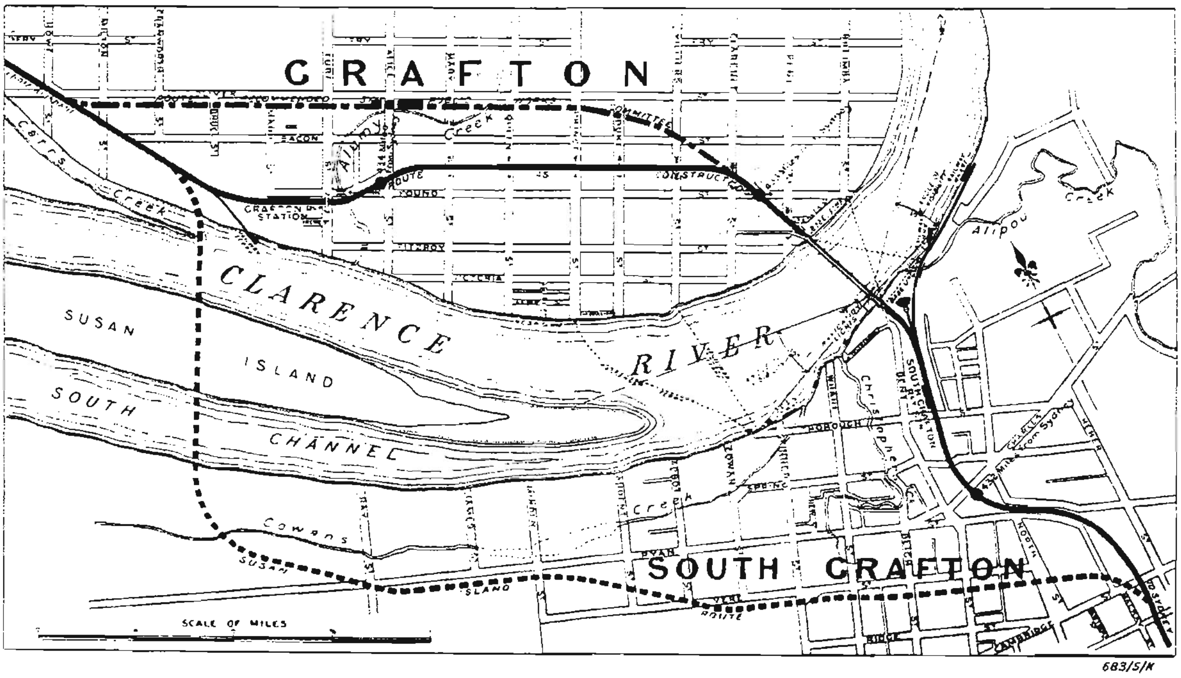



*Fig. 1.—Plan of Clarence River showing Alternative Railway Routes, Grafton to South Grafton and Location of Bridge.*

deposits of an earlier type consisting of bands of shale and of tenacious clay, varying in colour, resulting from the decomposition of the original shale beds. Location and depth of bores are shown on Fig. 2.

On account of a strong opposition in the district to the Wilson's Hill route, an alternative scheme was considered at the same time, crossing Susan Island above the navigable limit of the river for all but the smallest vessels. As the estimated cost via this route was nearly double that of the original proposal and its only merit was the elimination of the bascule opening, it was rightly abandoned.

## Railway Design.

Before working drawings were put in hand, a complete re-investigation was made of the question of most efficient form of pier, method of sinking to a rock foundation, the economic span for the general length and best type of bascule opening. A solid pier in one unit from top to base was finally decided on for piers Nos. 2, 3, and 4, to be sunk to rock by means of rectangular steel caissons, using the pneumatic process. In the shallower water at the northern end, cylinders would have been, no doubt, satisfactory but uniformity of procedure was desirable and caissons of a smaller base and height were adopted for the last three river piers. For the pier in the southern bank, already described as of a clay character, an open excavation, suitably timbered, was considered feasible and economical.

The adoption of the more massive pier, involving increased cost, led, logically, to the selection of a longer span. By substituting five 240 ft. spans for the six 200 ft., a saving of one pier was effected and it was found, at a later stage, that the substructure as modified approximated in cost to the superstructure, thus satisfying the criterion for economy.

The bascule span was to have been of the Scherzer rolling type, 82 ft. 6 in. centre to centre of bearings. The horizontal swing type of moving span had been ruled out in 1910, chiefly on account of the height of the pier and its size to carry an adequate system of rim rollers. Serious consideration was given, at this later stage, to the direct vertical lift type but, in spite of its many merits, the headway required to pass vessels with 85 ft. masts was a factor that, coupled with other advantages of the rotating and rolling Scherzer type, made the adoption of the latter justifiable.

The design of the railway bridge, as amended, was approved and a start was made on the working drawings in the early part of 1921. The train loading originally adopted conventionally known as Cooper's E50, was adhered to. The footway loading was taken as equal to 100 lb. per sq. ft. Impact due to moving engine loads was assessed by the formula :

$$I = f \div \left(1 + \frac{L^2}{30{,}000}\right)$$

Where $f$ is the calculated stress in the member due to the engine load ;
$L$ is the length of single track carried by the member.

This increment was taken into account in the design of the bearings but not of the concrete in the piers. The wind loading was taken as equal to 30 lb. per. sq. ft. on one and a half times the vertical projection of the structure, together with a moving lateral load of 300 lb. per lineal ft. applied 6ft. above top of rail. The longitudinal force arising from the acceleration and retardation of trains was taken as 20 per cent. of the train loading applied at the top of the rail.

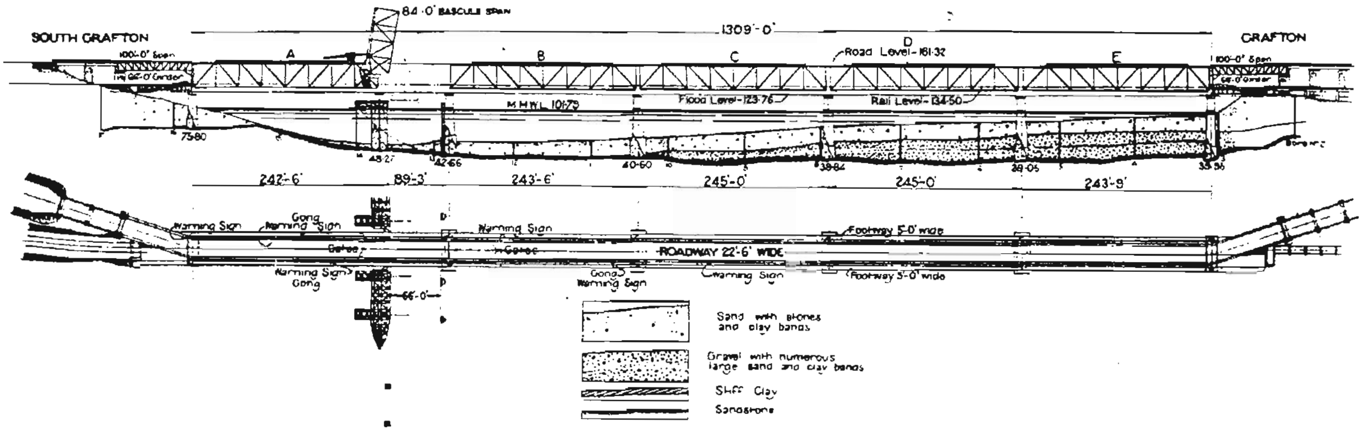



*Fig. 2.—Section of River showing Bed and Rock Levels and Trial Bores, Elevation of Bridge, and Position of Warning Devices.*

A list of the unit stresses adopted, representing the standard practice of the recent New South Wales Government Railways and Tramways Department, is given in Appendix " A."

## Road and Railway Design.

In December, 1922, when drawings for railway design were well advanced, the Minister for Works requested the Railway Commissioners to prepare designs and estimates for a bridge to carry vehicular, in addition to railway and pedestrian, traffic.

Alternative schemes were considered, one with road and railway at a common level and the other with road at a higher level which would give standard clearance from its structural support to the railway loading line. Consideration was given also to the possibility of a joint use deck. On account of the fairly frequent train service—passenger and goods—anticipated on the bridge over the Clarence River, this last proposal was deemed impracticable. Of the other two schemes the double deck design was not only much the cheaper but enabled all calculations

and drawings prepared to date for caissons and piers to be utilized. The only disadvantage was the long viaduct and embankment, about 15 chains in all, required on the northern side of the river to provide an acceptable grade—1 in 25—for the roadway approach from existing streets. The southern bank being much higher did not present any difficulty. This scheme was eventually approved, an extra footway being provided, also at rail level, at the request of the Public Works Department, and fresh drawings for the superstructure of the fixed spans and the bascule were then put in hand.

The Scherzer type of opening was no longer tenable on account of the double deck and a study was made of other methods. It was finally decided to adopt the Rall type as this possessed at least one of the advantages of the Scherzer method, though in a minor degree, namely, a rolling hinge as against the fixed trunnion of other types. Reduced friction and a wider opening for a given angle of rotation were thereby gained.

No extra pier was involved as the track girders which carried the rollers of the moving leaf were supported at one end on the batter braces of the adjoining span and at the other on a column standing on the lower chord. No increase in the size of piers was needed as the extra weight due to the roadway stabilized them without adding materially to the overturning moments. Skew spans were introduced at each end to divert the roadway from its location over the railway, thus enabling it to descend to its ultimate levels, as described above.

## Caissons.

The lower caissons form a permanent portion of the pier base. Three were required for the deep channel piers and covered an area, inside cutting edge, of 55 ft. x 20 ft. with a height of 27 ft. and three for the piers in shallower water, an area of 50 ft. x 15 ft. with a height of 17 ft. 6 in., see Fig. 3.

The cutting edge was a 15 in. x $\frac{7}{8}$ in. plate projecting its full thickness from the surface of the outer shell and stiffened by two internal 4 in. x 4 in. x $\frac{1}{2}$ in. horizontal angles and vertical diaphragms between outer shell and sloped sides and ends of the working chamber. Connecting rivets were $\frac{7}{8}$ in. diameter and in the bottom row every seventh rivet was omitted, leaving holes at about 2 ft. centres to permit the gradual escape of air and prevent dangerous blow-outs below the cutting edge. The chamber was 7 ft. 9 in. high, lined with $\frac{3}{8}$ in. plate, and roofed transversely with plate web girders, spaced 5 ft. centres. Access was provided by steel tubes $\frac{3}{8}$ in. thick, 3 ft. diameter, built up in 10 ft. lengths to form two vertical shafts from roof of chamber to bottom of air locks.

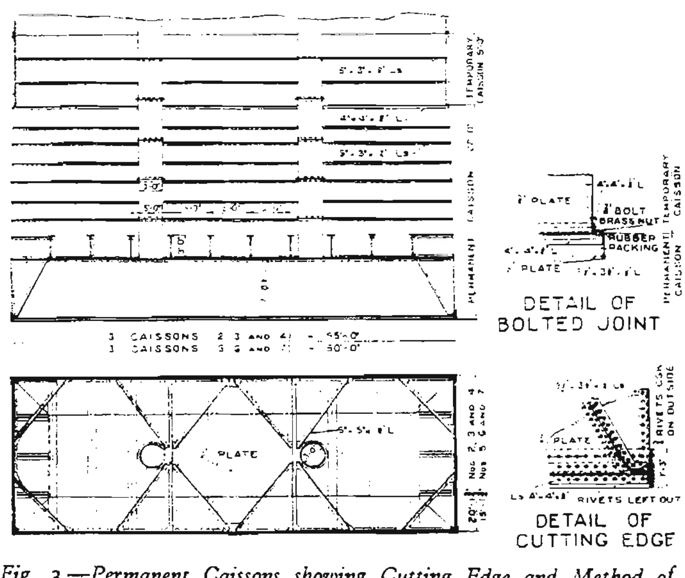



*Fig. 3.—Permanent Caissons showing Cutting Edge and Method of Attaching Temporary Caissons.*

The outer shell, of $\frac{1}{2}$ in. plate, was stiffened and braced to resist, when tommed, the external hydrostatic pressure before the concrete was placed. The horizontal joints were lapped, each upper plate lying inside the lower, giving a total effect, including the cutting edge, of 1 in 100 vertical batter on all sides which facilitated sinking. The inner angles of the cutting edge, on the other hand, formed a bearing surface which stabilized the descent, preventing sudden movements which would have imperilled the workers. The vertical joints of the shell were butted and covered. All external rivet heads were countersunk, likewise the internal heads in the access shafts. Seams throughout were caulked or packed to ensure air and water tightness; rivets $\frac{3}{4}$ in. diameter, except in cutting edge. The weight of each of the large caissons, as erected, was 107 tons and of each of the small ones 74 tons, but no section of any caisson, as despatched from the shops, exceeded 5 tons in weight.

The six temporary caissons were simply light steel shells, 9 ft. high, each constructed in four sections, fixed together and to the permanent caissons by means of $\frac{7}{8}$ in. diameter steel bolts with square necks and brass nuts, square holes being punched in the connecting angles. They were made in the first place to fit the large permanent caissons and altered in the field at a later stage to suit the small ones. Their function was to act as removable coffer dams inside which the forming for the shaped portion of the concrete pier above the base could be constructed and the concrete poured in the dry.

During the erection of the piers, it was found desirable to provide further temporary caissons to expedite the work and enquiries showing that steel would be expensive and take too long to manufacture, a timber type was designed and two units constructed in the field. Under favourable conditions, these, no doubt, would have served the purpose but, unfortunately, they were damaged in a minor flood while in service on pier No. 3, and in consequence, the completion of this pier was very much delayed.

The steel caissons proved a highly satisfactory method of sinking and all piers were founded within an inch or two of their proper locations. Provision had been made in the design for a considerable departure in this respect along both axes of the base.

The level roof of the working chamber, however, proved difficult to pack tightly with concrete and a slight slope downward from the shafts would have been advantageous.

## Fixed Truss Spans.

The provision of a high-level roadway necessitated some radical alterations in the design already carried out for the five fixed truss spans for railway only. It was evident that the polygonal top chord of the original design was now unsuitable and parallel chords were accordingly provided. The vertical railway clearance and proportions of the bascule span determined the relative levels of the railway and roadway decks and it was essential to limit the distance from the lateral bracing, part of which carried the road deck, to the centre of the top chord so as to stiffen efficiently the latter in a lateral direction. These factors led to the adoption of a vertical distance between chord centres of 35 ft. which, for a span of 240 ft., was considered a fair approximation to the economic ratio. The panels moreover, were increased to 30 ft. in length and the truss

design, thus simplified, brought about comparative economies that, to some extent, offset the extra cost of carrying the road deck and traffic. On the aesthetic side, however, it must be admitted there has been a distinct loss. As the former lateral spacing of the trusses, 28 ft., provided a road deck 22 ft. 6 in. between kerbs, there was no need to vary this dimension which had been fixed to suit lateral railway clearances. See Figs. 4*a* and 4*b*.

The *railway deck* is of the usual open type with stringers at 6 ft. 6 in. centres, 4 ft. 9¼ in. deep, riveted to the webs of the cross girders, 5 ft. 6½ in. deep, over angles, riveted in turn to the truss posts.

The *two 5 ft. footways* are carried at about rail level on light brackets outside the trusses. Hardwood decking is provided and fencing of galvanized iron piping, with panels of woven wire mesh.

The *roadway deck* rests on rolled steel girders supported at the ends on frames between the truss posts, these frames serving also as sway bracing for the trusses. The deck consists of a reinforced concrete slab of total thickness 8½ in. the top layer 1½ in. thick being of richer mixture to allow for wear under traffic and for waterproofing. This layer was ignored in the design of the slab. A transverse camber of 2 in. is provided. Transverse joints are provided at the panel points, dividing the road slab into 30 ft. sections and at the ends of spans sliding chequer plate joints are provided to allow movement between adjacent spans. Steel lattice fencing is provided over the end panels and around the pedestrian refuges above three of the central piers.

The roadway deck slab and girders were designed to carry a motor lorry of 12 ft. wheel base, 6 ft. track, with axle loads of 18,000 lb. on the front and 36,000 lb. on the rear axles, the rear wheels having double tyres. An impact allowance of 30% was made. The steel framework supporting the girders was designed to carry the above load in a position to develop maximum stress in members, and, alternatively, to carry a uniform load over the whole road area of 100 lb. per sq. ft.; the truss members to carry a uniform load over the whole of the roadway and footway areas of 50 lb. per sq. ft., combined with railway loading on two tracks located for maximum effect.

The shortening of the top chords under load would tend to cause compression of the roadway slab and girders with consequent bending in the top channels of the sway frames, shear in the rivets connecting them to the posts and bending in the posts. To reduce this effect, provision is made for the sliding of the two outer roadway joists at each side on their bearings on the cross channels. The three inside girders are riveted to the channels of the sway frames and the necessary lateral rigidity is thus ensured, without undue flexure of the channels or severe shearing stress in the rivets of the cleats, while the concrete is relieved also of high secondary stress.

The *trusses* have a few noteworthy features. The top chords are of heavy section and are spliced at the panel points; effective bearing of machined faces at joints is assumed and the rivets in the splices are designed to transmit only 60% of the compression. The bottom chords consist of two built channels, with flange angles turned inwards to permit square ends on cross girders; the channels are considered to have sufficient lateral rigidity to obviate the necessity of bracing by lattice bars and they are connected merely at intervals by tie-plates. The splices are made at panel points, being laminated, the gussets furnishing most of the necessary splice material.

The web members, except hip vertical and centre posts, are built " I " sections, composed of plates and bulb angles, the latter being used to give an adequate radius of gyration without recourse

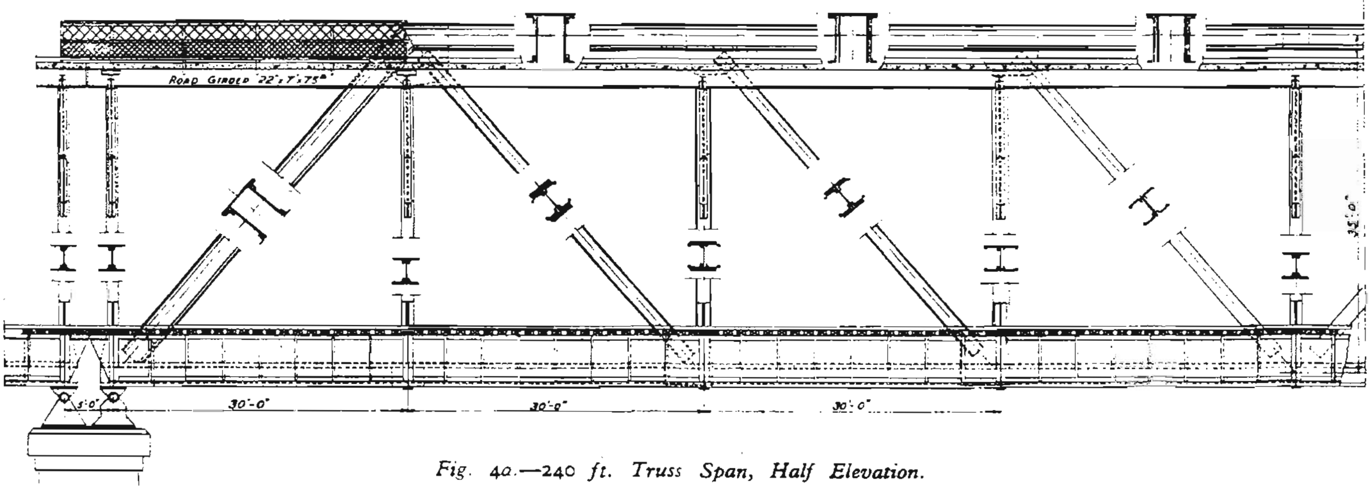



*Fig.* 4*a*.—240 *ft. Truss Span, Half Elevation.*

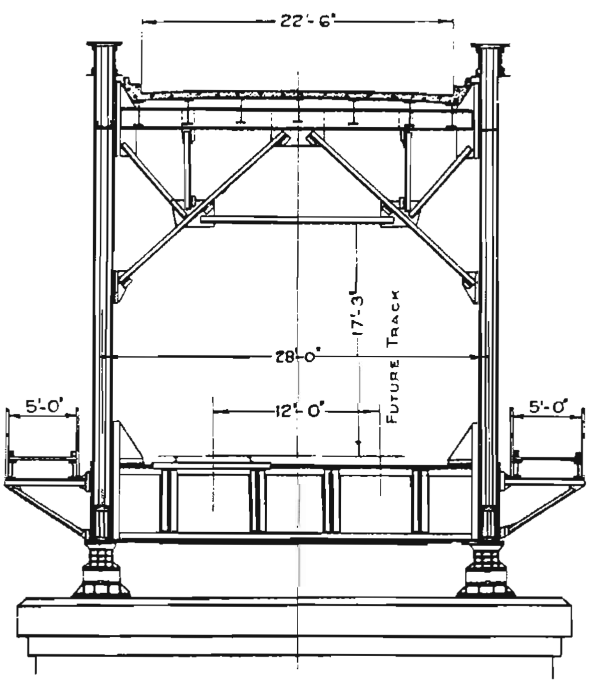



*Fig.* 4*b*.—*Cross Section,* 240 *ft. Truss.*

to latticed sections. The members are slightly heavier than the latticed type of the same capacity, but involve less shop labour; their appearance is unusual but definitely satisfying. The vertical posts are carried up into the top cords, providing needed lateral support; as it is impracticable to continue the posts into the bottom chords, diaphragms are used in the latter.

A light lateral system is provided below the top chords, riveted to the posts, and the framework carrying the road girders acts as part of this system and as sway bracing in the vertical plane. The roadway deck itself contributes substantially to the lateral stability at this level.

The main lateral system is attached to the bottom chords of the trusses and supported by the stringers. The system adopted to resist tractive and braking forces in the two central panels is novel and simple and provides for full braking or acceleration on both tracks, 125 tons per track, in one direction or in opposite directions simultaneously. The provision of bracing for this purpose is a common feature of German designs and, more recently, has been introduced into Britain and America.

The trusses are fabricated with a camber of 2½ in.; the top and bottom panel points are calculated as lying on an arc of concentric circles with the posts on radii, the diagonals being arranged on lines joining panel points. About ½ in. of the camber is removed under dead load and to ensure an even track another inch is taken out by variation of the thickness of transoms from 7 in. at ends to 6 in. at centre.

The *cast steel bearings* show no departure from accepted practice. The full height of bearings at fixed and expansion ends is kept the same, 4 ft. 1 in., to enable the pier top to finish at one level. In the expansion bearings, six segmental rollers, 12 in. diameter x 4½ in. wide x 32 in. long are provided; teeth are fitted to the end rollers and work in pockets in upper and lower castings; these in conjunction with pinned-on side bars, ensure that the six move in unison. Central top grooves check the lateral displacement and shaped stops on their ends prevent collapse. The whole nest is encased in a galvanized iron cover to exclude all dust, etc. Hinge pins are 9 in. diameter x 20 in. long.

The truss spans at each end, 96 ft. mean length, which carry the roadway clear of the railway are built on a skew of 18° from the bridge centre line and one truss is about 9 ft. longer than the other. The expansion end of these spans is carried on a pair of steel columns, supported on the end river piers which are of sufficient flexibility to provide the requisite movement.

The terminal footway truss spans are 66 ft. long and constructed to a ramp of 1 in 5. A pedestrian subway 8 ft. wide connects each pair at the lower level.

One railway track only, on the upstream side at each end of the bridge, is carried from river pier to subway wall on a standard deck plate girder span 64 ft. centre to centre of bearing plates. the girders being 7 ft. deep, spaced 6 ft. 6in. centre to centre.

The weight of structural steel in a normal 240 ft. span, not modified to suit the bascule span requirements, is 556 tons. The maximum practicable load on a bearing, with train in position on each track to give maximum reaction and roadway and footway completely covered with load of 50 lb. per sq. ft., is made up as hereunder:

| | | |
|---|---|---|
| Standard *E*.50 train load ... ... ... ... ... | 338 | tons. |
| Standard impact —11½% ... ... ... ... | 39 | „ |
| Roadway and footway load ... ... ... ... | 46 | „ |
| Dead load ... ... ... ... ... ... ... | 246 | „ |
| Total: | 669 | tons. |

The bedplate measures 4 ft. x 4 ft. 6 in., or 18 sq. ft. and thus transmits a stress of 578 lb. per sq. in. to the 4:2:1 concrete on which it is bedded. The bearing pressure on the segmental expansion rollers for above load, less the portion below rollers, amounts to 681 pounds per linear inch per inch of diameter. The maximum stresses in the truss members for dead, railway, highway, pedestrian, impact and wind loading are given in Fig. 4*c*.

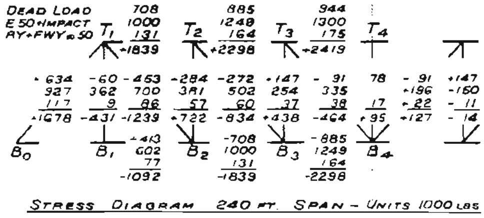



*Fig. 4c.—Stress Diagram, 240 ft. Truss.*

## BASCULE SPAN.

The bascule span is of the Rall (combined rotating and travelling) type, constituted, principally, of the leaf trusses, counterweight frames and counterweight, in conjunction with the supported railway, footway and roadway decks. See Figs. 5*a*, 5*b*, 5*c*, and 5*d*.

The *leaf trusses* are of the Pratt type, in four panels, each 21 ft., making a span of 84 ft. The chords are parallel with a depth of 28 ft. 6 in. between centres and a distance of 28 ft. between central vertical planes of the trusses. The top and bottom chords are each of two rolled steel channels, latticed, with the top chord flanges outside, allowing the vertical web members to project so as to connect with the top chords of the sway frames, and the bottom chord flanges inside to facilitate the connections of the cross girders and lateral bracing. The vertical web members and end post *T*3-*B*4 are built up "I" sections. The diagonals are each of two rolled steel channels, latticed, with flanges inside.

The *counterweight frames* vary in depth with one panel 21 ft. and one panel 11 ft. between *T*4 and the centre of the side plate of the counterweight box at *T*5. The members are built-up "I", latticed channel and compound sections.

The counterweight frames are connected to the leaf trusses at *T*3, *C* and *B*3 and spaced 24 ft. centres of vertical planes to clear the track girders and end posts of the fixed trusses of span *A*. The compound members *T*3-*L*4 were designed to transfer the components of the roller reactions to axial forces in the counterweight frames and are double connected to the latter at *L*4 and the leaf trusses at *T*3. Two special sway frames, each on opposite sides of the roller pins at *L*4, transmit the other component forces of the roller reactions to the counterweight frames.

The *counterweight box* is fabricated of steel angles, channels and plates. The main box is divided by three diaphragms into four cubicles. Five rear cubicles and three bottom cubicles are attached to the main box. The five rear cubicles extend below the rail level (bascule in the fully open position) between the stringers in the adjacent panel of the fixed span *A*; these stringers are spaced 5 ft. centres on each track and carry the rails on longitudinal timbers. The main box is diagonally braced, with channels and gusset plates, to transfer forces from the top plates of the rear cubicles and, during the elevation of the bascule, loads from the main box to the end plates. The counterweight cubicles are filled with the required quantity of cast iron blocks and lead set in 1 to 3 cement grout.

The *railway deck* is of the open type; the rails are supported by timber transoms bolted to plate girder stringers, 3 ft. 6¼ in. deep over angles. The stringers are cleated to the wsbe of the cross girders which are 4 ft. 6¼ in. deep over angles and are riveted to the vertical web members and bottom chords of the leaf trusses.

The two *footways*, each 5 ft. wide, are constructed similarly to those on the fixed truss spans.

*Roadway deck*.—The roadway level at the kerb is 2 ft. 10½ in. above the centre line of the top chord of the leaf trusses and 26 ft.

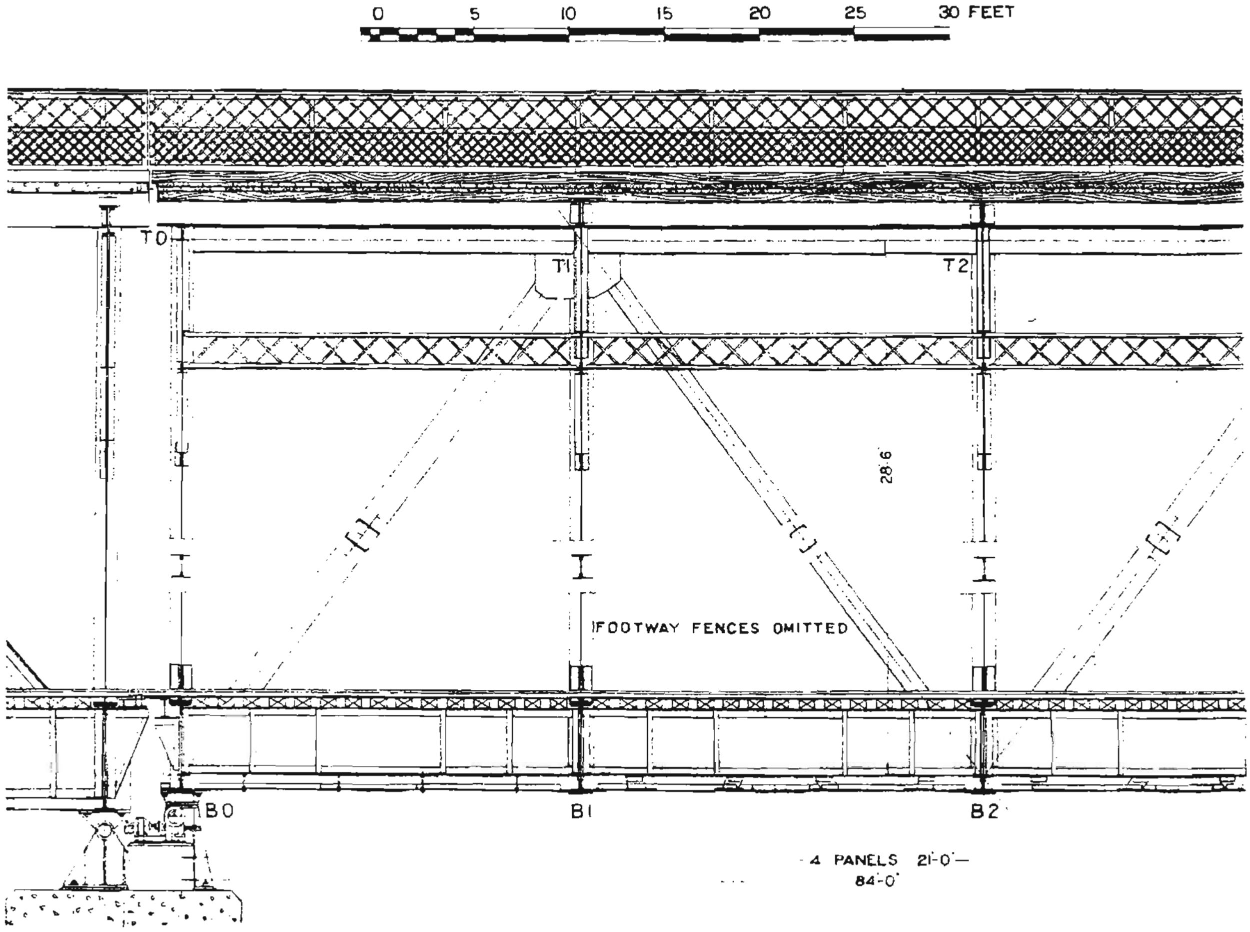



*Fig. 5a.—Elevation of*

10 in. above the rail level. The roadway deck is carried on rolled steel stringers which cantilever over the top chord of the sway frame at *T*0 and are cleated to the top chords of the intermediate sway frames and counterweight box. The deck, extending from the chequer plate facing at *T*0 to the counterweight box, is constructed of two layers of 9 in. x 3 in. hardwood planks to a transverse camber of 2 in. The planks are laid diagonally in the respective layers at 60° to the centre line of the bridge and fixed by spiking to longitudinal timbers bolted to the flanges of the stringers. Two 12 in. × 9 in. timber kerbs are bolted to the deck, making a roadway 22 ft. 6 in. wide, from *T*0 to *T*2, narrowing gradually to 20 ft. 3 in. at *T*3 and extending at constant width to the counterweight box where concrete paving and kerbing are provided to cover the cast iron blocks in the main counterweight box; the roadway continues at the width of 20 ft. 3 in. to the southern gates, thence diverging to 22 ft. 6 in. wide at *T*2 on the fixed span *A*.

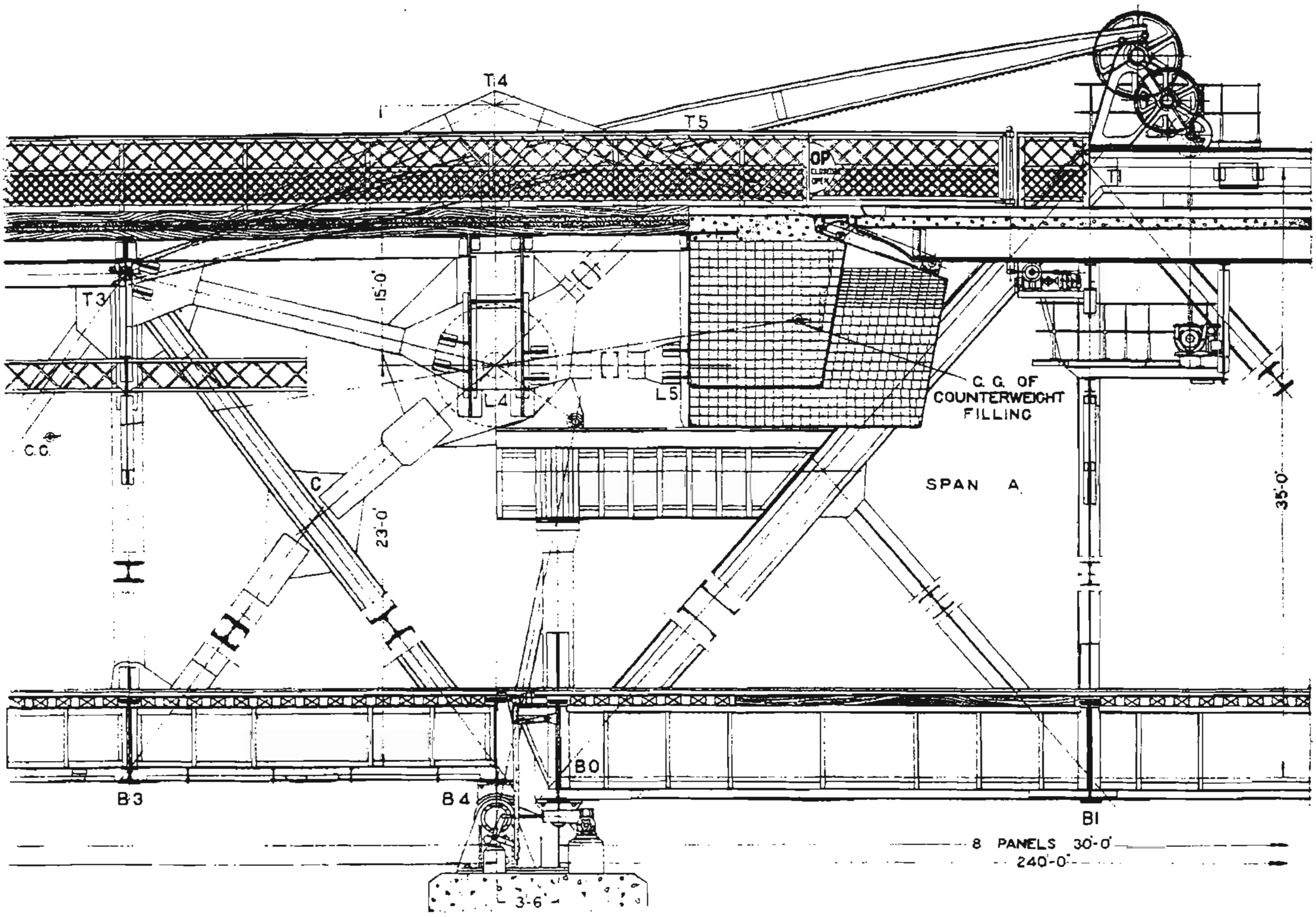
The *bottom lateral bracing* and braking frames, incorporated in the two inner panels, are constructed of steel angles connected by gusset plates to the truss chords and the bottom flanges of the cross girders and suspended from the stringers at the intersecting points. The braking frames, in addition to braking and tractive forces, also resist gravity forces of the deck during elevation of bascule.

The *top lateral bracing* in panels *T*0 to *T*3 consists of steel angles riveted to gusset plates. and to the bottom flanges of the roadway stringers. The bracing from *T*3 to the counterweight box is fixed in the planes of members *T*3-*L*4 and *L*4-*L*5 and constructed of members built-up of four angles and lattice bars. The bottom chords of the sway frames are laterally supported during the elevation of the bascule by a light latticed member extending from *T*0 to the counterweight box.

The weight of the bascule span, not including the controlling links, is made up as under :—

| | | |
|---|---|---|
| Structural steelwork including road fences ... | 243.1 | tons. |
| Mechanical and electrical equipment mounted on bascule ... ... ... ... ... ... | 32.1 | ,, |
| Cast iron counterweighting blocks... ... ... | 448.0 | ,, |
| Lead counterweighting blocks ... ... ... | 30.0 | ,, |
| Armour concrete counterweighting ... ... | 29.3 | ,, |
| Timber: Roadway fence capping, decking and kerbing ... ... ... ... | 45.9 | ,, |
| Footway decking and kerbing... ... | 3.8 | ,, |
| Railway transoms ... ... ... | 7.5 | ,, |
| Footway fences ... ... ... ... ... | 3.0 | ,, |
| Tar and sand on roadway ... ... ... ... | 2.3 | ,, |
| 80-lb. rails and 100-lb. guard rails and fastenings | 5.0 | ,, |
| Total: | 850.0 | tons. |

The whole weight of the bascule span, excepting the preponderance of approximately 2,500 lb. on the lock bearings, together with deadload on the fixed end bearings of the fixed span *A* and the resultant due to the superimposed live loads and impact, are carried by the *double bearings* on pier No. 2. The maximum pier reaction on each bearing is 1,174 tons, giving a bearing pressure on the concrete of 570 lb. per sq. in. The bearings of the fixed span *A* rest on pins similarly to the other fixed bearings.




*Bascule Truss Span.*

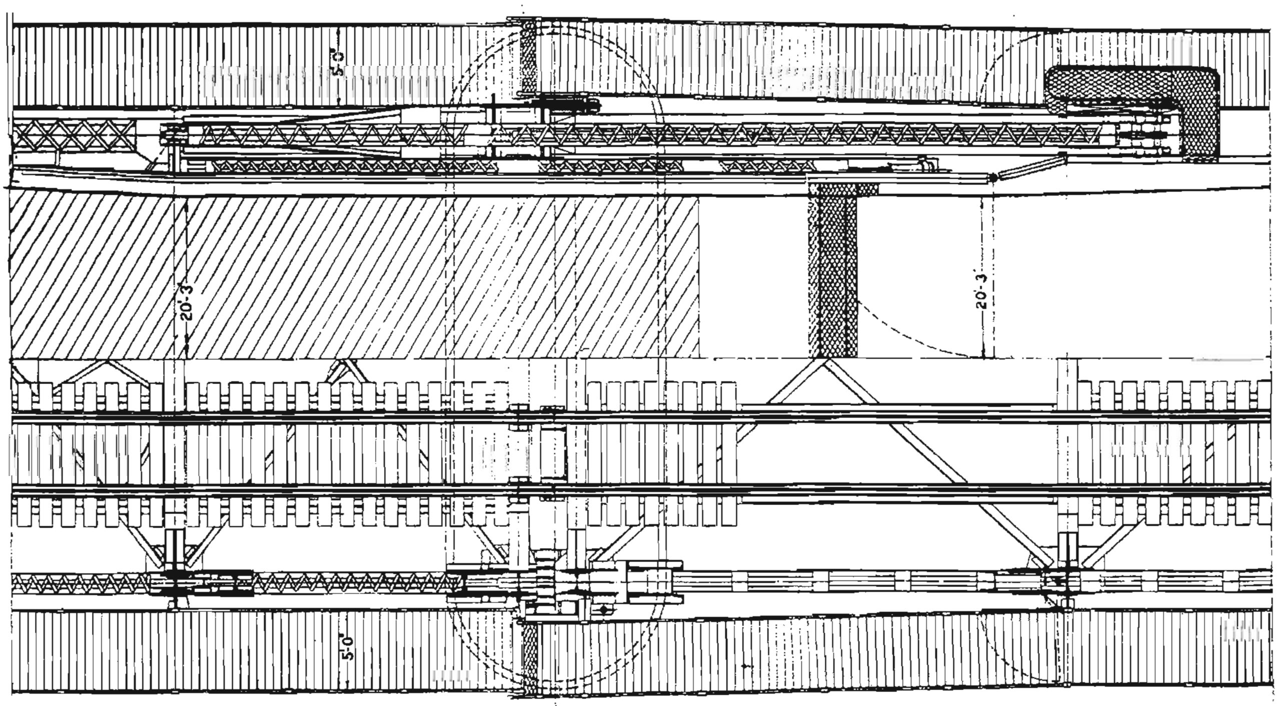



*Fig. 5b.—Plan of Bascule Truss Span.*

The shaped shoes, on the bascule at the hinged end, bear on grooved rollers, phosphor bronze bushed, mounted on 14 in. diameter steel pins.

The particular functions of the *grooved rollers* are :

(1). To provide the necessary diameter for the satisfactory disengagement of the shaped shoes ;
(2). To provide a medium for the bascule to rotate upon during the initial opening and final closing stages ;
(3). To ensure during re-engagement of the shaped shoes that the bascule returns to the normal lateral position ; and
(4). To provide dustproof and efficiently lubricated axes.

The bearings at *B*o on pier No. 3 carry the nominal dead load preponderance abovementioned, in addition to what is due to superimposed live loads and impact. These bearings provide for expansive movements due to temperature changes in the bascule leaf and house the lock bars and screw reduction gears described in detail under locking gear.

*Track Girders.*—The bascule, in operation, is supported by 7 ft. diameter rollers which travel horizontally on two track girders of box type, each with three webplates spaced at $8\frac{1}{2}$ in. centres.

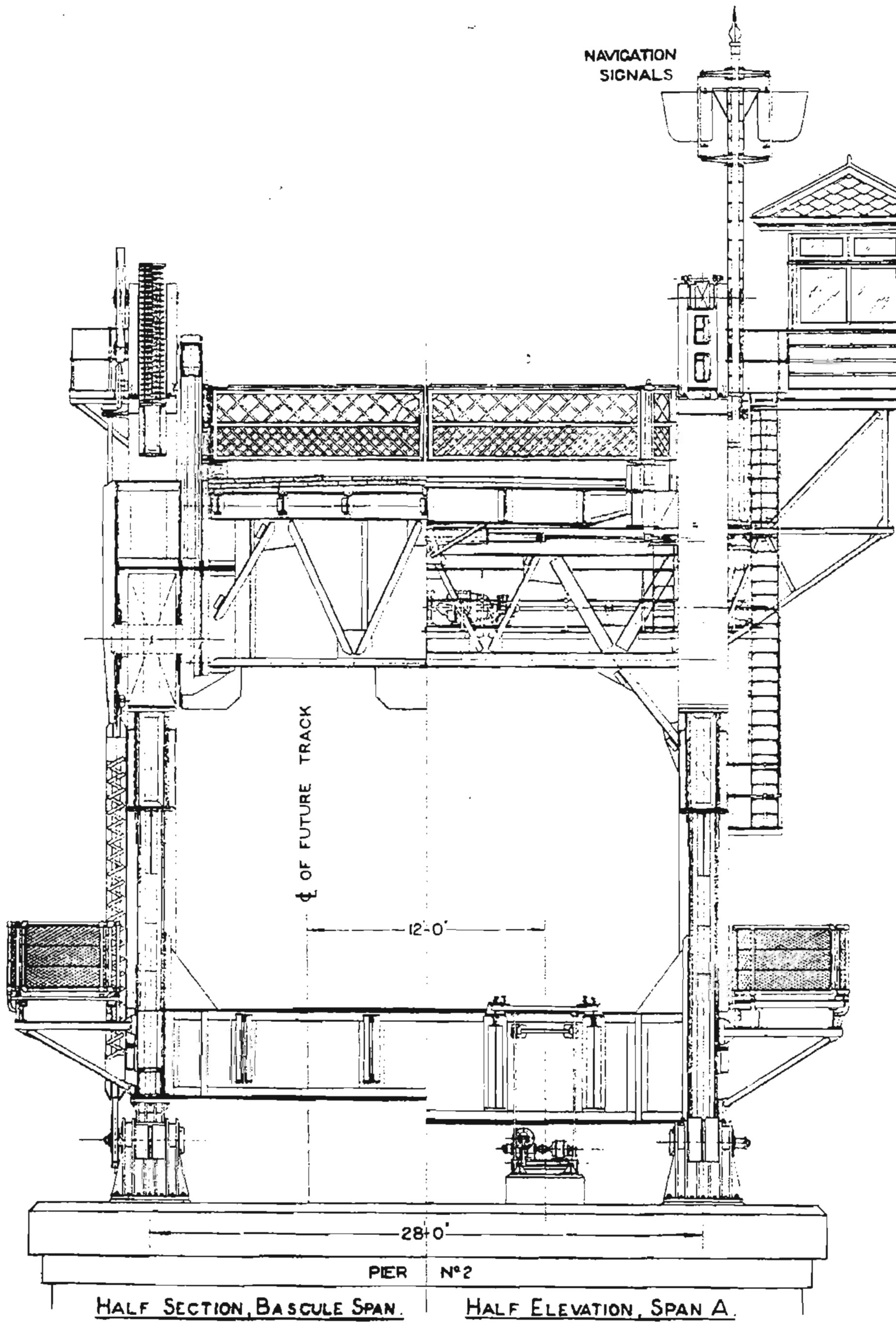



*Fig. 5c.—Cross Section of Bascule Truss Span.*

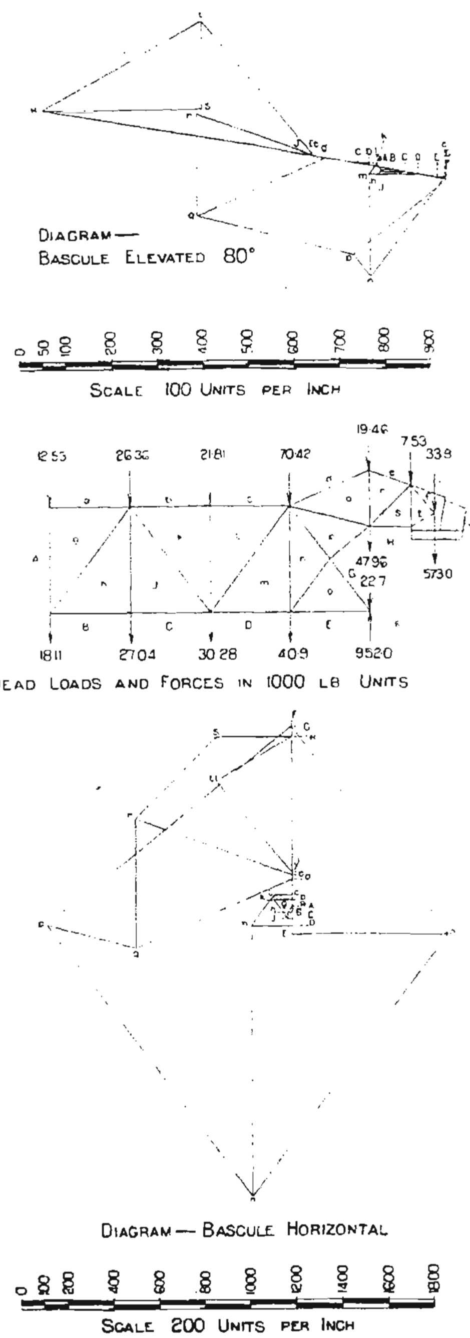



*Fig. 5d.—Stress Diagram, Bascule Truss Span.*

The outer webs extend through the end posts of the fixed trusses *A* to form gussets connecting with the diagonal struts which support, in conjunction with the above end posts, the southern ends of the track girders. The centre webs are connected to diaphragms 10 ft. 7 in. from the centres of the columns supporting the northern ends. The lower ends of these columns are connected to the fixed trusses *A* and the end cross girder. Knee plates, forming parts of the column and cross girders webs, make a very effective junction to resist bending due to lateral forces transferred from the bascule to the track girders during operation.

The top edges of the web-plates are reinforced by side plates and channels; the top surfaces of the assembled steelwork are planed to ensure even bearing on the planed faces of the track plates. The top faces and edges of the track plates were planed to 29¾ in. x 1¾ in. subsequently to assembling and flush riveting on top. Particular care was exercised in design to provide effective riveting of the side plates and channels to the web plates.

The width of track plate in effective load contact in each girder is 22 in. giving a pressure of 515 lb. per in. of diameter per in. of face. See Appendix B.

*Controlling links.*—The horizontal movement of the bascule is controlled by two spring-compensated links which connect extensions of gusset plates at *L*4 with the cantilevered pins in the roller bearings at *B*4. Each link consists of two latticed and batten-plated channels with flanges outside, fitted at the upper end with a forked cast steel head and bearings and at the lower with a cast steel head mounting a sliding bearing with a compensating compression spring, adjusting screws and lock nuts.

The function of the compensating heads is to allow variations in the distance between the link bearings within fixed limits, in order to eliminate extreme stresses in the links and bearings due to the elastic deformations of members in the counterweight frames and leaf trusses during the transference of loads from the bascule bearings at *B*4 to the track girders and vice versa. The compression springs are screwed down to minimum loads of 30,000 lb. at the maximum spring extension to maintain the links at constant length by resisting compression forces due to tractive resistance of the rollers and to wind forces during the control of the horizontal movements.

*Principle of operation.*—The operating and controlling forces are applied respectively to the bascule span at the panel point *T*3 by the rack links of the main operating gear, and to the gusset plate extensions at *L*4 by the controlling links described above. At the outset the main rollers hang about $\frac{3}{32}$ in. clear of the track girders and centrally over the grooved rollers below.

The initial opening movement is a rotation about the axes of the grooved rollers and extends from the closed position to point where the rollers, after describing an arc, come in contact with, and commence to transfer load to, the track girders. During the next period the complete moving load is gradually transferred to the track girders and this transitional stage is accompanied by elastic deformation in certain members of the bascule, in the track girders, columns and links with a definite extension in the latter case of the compensating springs. On the release of load from the grooved rollers, the shoes commence to disengage from their bearings and simultaneously the bascule, governed by the controlling links, develops angular movements about the main roller pins combined with horizontal translation on the track girders. The leaf opens to a maximum angle of 80° with a total horizontal displacement of the main roller pins of 12 ft. 6 in. For experimental data, see Appendix B.

*Operating forces.*—The centre of gravity of the complete bascule span and counterweight is 1.32 in. from the vertical plane through the main roller and grooved roller axes, owing to the allowed preponderance of 2,500 lb. at the locking bearings. This displacement of the gravity centre produces a moment about the grooved roller axes which resists the opening operating forces at *T*3 until the gravity centre has moved vertically over the grooved roller axes, thence the moment assists these forces until static balance occurs during the transition period. The latter moment resists the operating forces during the final closing stages until the gravity centre is again vertically over the grooved roller axes, and this imposes a heavy duty on the gearing but, as the wind pressure in this position under the most adverse conditions, is considerably reduced, the gears are not loaded to the full capacity.

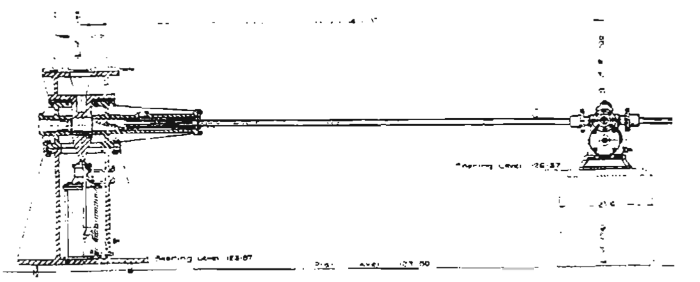
## Bascule Machinery.

The bascule is operated by two sets of *lifting gear* mounted, principally, on the top chords of the fixed span *A* near the panel points *T*1. Each set contains a train of five pairs, giving a gear reduction on the main pinions of 1 in 118. Two 33 h.p. motors are mounted on the gear platform which also carries the first motion shafts and encased bevel gearing. Vertical second motion shafts transmit the power to the gear sets above.

*Gear teeth* are of the involute type cut from the solid with an obliquity of 15°, excepting those in the rack links and meshing pinions which have an obliquity of 20°.

The *rack links*, 59 ft. 5 in. from centre of pin to end, meshing with the main pinions of the gear sets and pin connected to the bascule panel points *T*3, are structurally of open box section, latticed and diaphragmed, varying in depth over angles from 2 ft. 6 in. at 22 ft. from the head to 1 ft. 4½ in. at the head and 10 in. at the gear end. Each link mounts a cast steel head, gunmetal bushed, and houses between the webs to the pitch lines, five sections of cast steel racks, each 7 ft. 8 in. long with twenty-three teeth 4 in. pitch and 8¾ in. face, making a total length of toothed rack of 38 ft. 4 in. with one hundred and fifteen teeth.

Braking control of the mechanism is effected by three electro-mechanical brakes—two motor-mounted service and one floor-mounted emergency brake.



LOCKING GEAR

*Fig. 6.—Locking Gear and Pneumatic Buffers.*

The *locking gear* consists of a worm reduction and a screw and nut movement in each locking bar. See Fig. 6. The cast steel locking bars are housed in the upper parts of the bearing pedestals and engage the tongues of the moving shoes on the bascule. The bars are tapered on the engaging surfaces to 1 in 4½ which imparts a drawing action, within the tolerance of the limit switch, on the bevelled faces of the phosphor bronze wearing blocks attached to the tongues of the moving shoes, and finish on parallel faces for 4½ in. of a total travel of 1 ft. 6 in.

A cushioning retardation is pneumatically imparted to the final closing movement of the bascule by means of air cylinder assemblies situated in the lower parts of the bearing pedestals. The pistons have a diameter of 9 in. and stroke of 13½ in. The descending tongues of the shoes make contact with fibre-protected ends of the piston rods and force the pistons against a compressive resistance. The desired amount of air-cushioning is obtained by reaming the orifices of the jets fitted near the bottoms of the cylinders. The pistons are replaced in position by springs.

The mechanism is driven by a 5 h.p. motor direct coupled to the worm shaft and fitted with a motor-mounted electromagnetic brake.

*Gate Operating Gears.*—The northern gates are located near the panel points $T2$ and $B2$ of the fixed span $B$, 67 ft. from the chequer plate facings at the junction of the fixed and bascule roadway decks. The southern gates are situated near the panel points $T1$ and $B1$ on the fixed span $A$. The latter gates have the dual function, alternately, of providing part of the fence at the counterweight end of the bascule while in the lowered position, with road open for traffic, and a traffic barrier in the raised position of the span.

The operating mechanisms are similar and the southern set only, therefore, is described. This consists of one worm and two screw reductions in one unit, mounted on a gear platform which is supported by the sway frame at the panel point $T1$ and by a frame attached to the roadway stringers. The combined phosphor bronze nuts and cross heads of the screw reduction gears are connected by two forked rods, one on either side, to arms keyed to the lower ends of the roadway gate stiles. Movement is transferred to the footway gates below by means of links connected to the above arms and to arms on the upper ends of two vertical shafts which turn in bracket bearings mounted on the vertical web members $T1$-$B1$ of the fixed span $A$; the lower ends of these vertical shafts are fitted with arms connected by links to arms keyed to the footway gate stiles. The gate stiles turn in cast steel pedestal bearings, gunmetal bushed, mounted on the roadway and footway stringers, respectively.

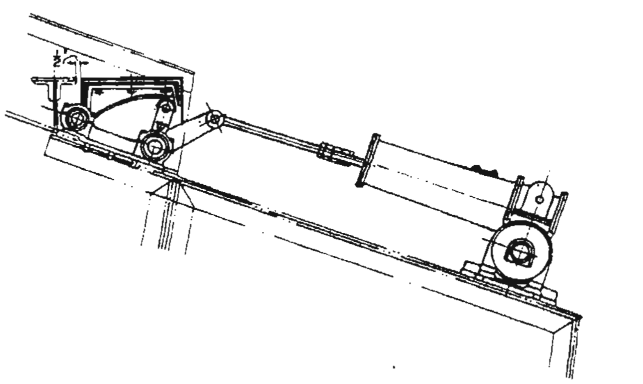


*Fig. 7.—Hinged Road Leaf Operating Gear.*

Extensions from the main gear platform and ladders provide access for maintenance and adjustments.

A platform is provided for the maintenance and adjustments of the northern gates, with access by ladder from the bottom chord of the fixed truss $B$.

Each gear is driven by a 5 h.p. motor, direct-coupled to the worm shaft and fitted with a motor-mounted electro-mechanical brake.

The *hinged road leaf* (see Fig. 7) is constructed of one rolled steel channel 17 in. x 4 in. with ½ in. reinforcing plates riveted on the flanges and a chequer plate 18 in. x ½ in. flush riveted to the back. It is curved to a camber of 2 in. in conformity with the adjacent facing chequer plates on the bascule and fixed roadways and is carried on six cast steel cams assembled between, and pivoted in, the upper twin bearings of six double cast steel bearings, gunmetal stepped and mounted on the sloping top of the main counterweight box.

The operating gear consists of a worm and screw reduction unit mounted on the rear downstream cubicle of the counterweight box. The combined phosphor bronze nut and cross-head of the screw reduction gear is connected by a forked rod to an arm keyed to a rocker shaft which turns in the lower twin bearings of the above double bearings, and mounts, between the twin bearings, six arms with forked ends fitted with phosphor bronze bushed steel rollers, which engage the curved surfaces of the cams.

The leaf has a hinged movement of 24° by cam action, in which the rocker shaft is turned through an angle of 85° by the worm and screw reduction unit.

The gear is driven by a 5 h.p. motor direct-coupled to the worm shaft.

The *rail lift* (see Fig. 8) is a movable section of the permanent way and its function is to provide horizontal clearance at the track level necessitated by the rotational movement of the bascule leaf about the grooved roller bearings at $B4$ during the initial opening and final closing stages.

The running rails, each 2 ft. 1 in. long, are connected by rivets and shaped plates to the back of one rolled steel channel 8 in. x 3 in. The shaped plates reinforce the rails as beams and are planed to give the rails a cant of 1 in 20. The ends of the lifting rails and of the adjoining rails on the bascule and fixed span are supported by four cast steel bearings, two bolted on the top flange of the bascule end cross girder and two bolted on knee brackets riveted to the end cross girder on the fixed span $A$. The ends of the rails on the bascule and the fixed span are bolted to the above cast steel bearings ensuring a constant gap for the accommodation of the rail lift.

The movement of the assembly of rails, plates and channel is controlled by two vertical links, pin-connected to brackets on the underside of the channel and attached by pins 1 ft. 1⅝ in. lower to arms mounted on a shaft which turns in two bracket bearings, bolted to the web of the cross girder of the fixed span $A$. The lower ends of the vertical links are fitted with straps, sliding heads and compression springs with adjusting screws. The sliding heads are

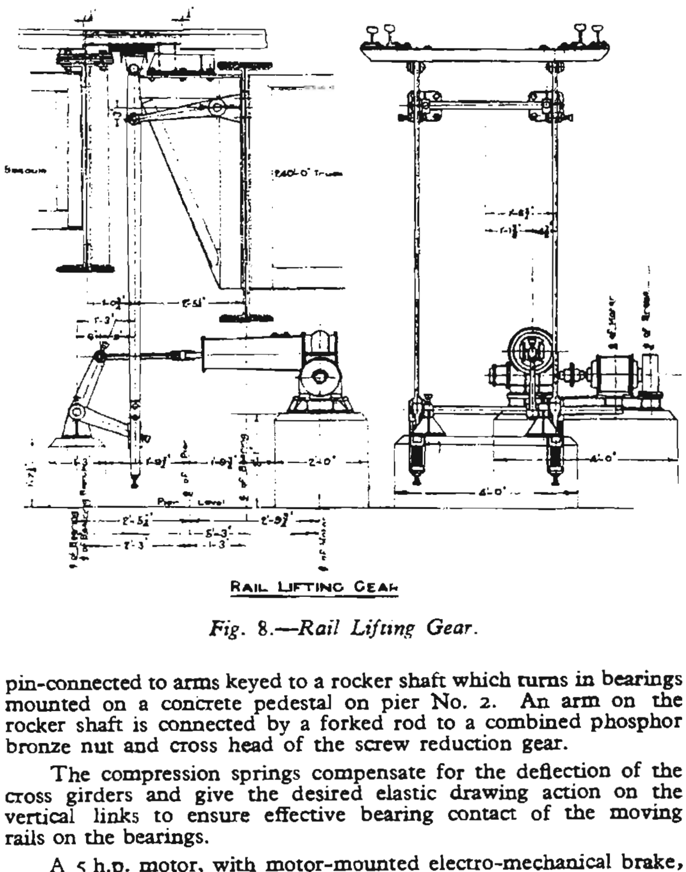



*Fig. 8.—Rail Lifting Gear.*

pin-connected to arms keyed to a rocker shaft which turns in bearings mounted on a concrete pedestal on pier No. 2. An arm on the rocker shaft is connected by a forked rod to a combined phosphor bronze nut and cross head of the screw reduction gear.

The compression springs compensate for the deflection of the cross girders and give the desired elastic drawing action on the vertical links to ensure effective bearing contact of the moving rails on the bearings.

A 5 h.p. motor, with motor-mounted electro-mechanical brake, is direct coupled to the worm shaft of a worm and screw reduction unit. The motor and unit are bolted to a cast steel base mounted on a concrete pedestal on pier No. 2.

The combination of links and levers imparts, during the operation, a combined lifting and retractive movement, giving both track clearance and clearance between the vertical links and the bascule cross girder. During construction, 100 lb. guard rails were added to the track on the bascule span and short sections of these have been fixed to the rail lift assembly to provide continuity.

## Electrical Equipment.

*Electric power* is generated at Nymboida and supplied by the Clarence River County Council.

The two *lifting motors* are of the slip ring induction type, each 33 h.p., 1,000 r.p.m. (synchronous), 415 volts,

3 phase, 50 cycles, totally enclosed, 15 minutes rated with temperature rise of 55° C., with a full load running torque of 185 lb. ft. and capable of developing starting and running torques 200% of full load running torque.

Each motor is fitted with an electro-mechanical service brake, spring set, motor mounted, which develops retarding torques ranging to a maximum of 185 lb. ft. by adjustment. An electro-mechanical emergency brake spring-set, floor-mounted, is assembled between the motors and is capable of developing a maximum retarding torque of 485 lb.-ft. The two service brake wheels are mounted on the flange couplings connecting the motor shafts to the first motion shafts; the flange couplings connecting the two motor shafts, mount the emergency brake wheel.

The locking, gate-operating, rail-lift and hinged leaf mechanisms are driven by five motors of the squirrel cage induction type, each 5 h.p., 1,500 r.p.m. (synchronous), 415 volts, 3 phase, 50 cycles, totally enclosed, 5 minutes rated with temperature rise of 55° C. Each motor, excepting the hinged leaf motor, is fitted with an electro-mechanical brake, spring-set, motor mounted, with retarding torque ranging to a maximum of 36 lb. ft.

The main sections of the control equipment comprise:

(1) Incoming supply panel;
(2) Main control panel;
(3) Push button panel; and
(4) Lighting panel.

The push button panel is supported on a flat steel framework attached to the floor and wall of the operating cabin and mounts five push button stations magnetically to control the five auxiliary motors, twenty indicating lights, one interlocked switch to control the navigation signal lights, one emergency button and one snap switch to control the warning gongs and illuminated signs.

The geared limit switch for the main lifting gear is mounted on the base of the main gear set near the operating cabin and is driven by the main pinion shaft through sprocket and chain drive and, in addition to limiting the movements of the main lifting gear, controls the indicating lights, which show *red* for nearly open or nearly closed, and *green* for open.

One track type limit switch, mounted on the downstream locking bearing governs the control circuit (at a tolerance within the limits of the locking bar drawing action) of the locking mechanism in the closing direction and controls the indicating light, which shows *white* for leaf closed.

Ten track type limit switches (two on each auxiliary mechanism), in conjunction with the two above limit switches, govern the control circuits for the operation of the main lifting and auxiliary mechanisms in the correct sequence. These limit switches also control red and white indicating lights on the northern gates, southern gates, hinged road leaf, rail lift, and lock.

The master switch, mounted on the cabin floor, controls the lifting motors. The acceleration of the motors is under the control of the operator for slower speed increments than provided by the limits of the definite time interlocks. When automatic acceleration is required, the switch is moved to the "full" position for either closing or opening the leaf.

In order to make satisfactory slow contact at the locking bearings, the foot-operated push button station controls the lifting motors with full resistance in the rotor circuits during the final closing stage, subsequently to the leaf arriving at the nearly-closed position.

## APPENDIX "A."

### New South Wales Government Railways and Tramways.

### Standard Rules and Formulae for Design.

*Extract relevant to design of Clarence River Bridge and Structures on the Grafton to South Grafton Railway.*

### Maximum Unit Stresses.

Each member of a structure shall be so proportioned that the unit stress due to any combination of live and dead loading will not exceed the particular value set out in list hereunder. Where this loading is further combined with longitudinal or wind or both of these forces, the allowable unit stress may be increased 25 per cent. beyond the value in list, provided the section so determined is not less than that required for dead and live loads. In this connection live load is considered to include impact and centrifugal forces.

| (*a*). *Working Stresses in Steelwork*:— | *lb. per sq. in.* |
|---|---|
| Tension axial, on net section | 18,000 |
| Compression axial on gross section with a maximum of 15,000 lb. per square inch. | $18{,}000 - \frac{80\,L}{R}$ |
| $L$ = Length of member in inches. | |
| $R$ = Least radius of gyration of member in inches. | |
| Direct compression on steel castings | 18,000 |
| Bending.— | |
| On extreme fibre of rolled or built sections, girders and steel castings (net section) | 18,000 |
| On extreme fibres of pins | 27,000 |
| Shearing.— | |
| Rivets, pins and turned bolts | 13,500 |
| Plate girder webs (gross section) | 12,000 |
| Bearing.— | |
| Rivets, pins and turned bolts | 27,000 |
| Expansion plates | 5,000 |
| Expansion rollers (lb. per lin. in.) | 675$d$ |
| Where $d$ is diameter of roller in inches. | |

| (*b*). *Working Stresses in Masonry, Concrete, etc.*: | *lb. per sq. in.* |
|---|---|
| Tension.— | |
| Concrete, 1:3:6 or richer concrete, not reinforced, cross breaking stress | 60 |
| Shear.— | |
| Concrete 1:3:6 or richer concrete, brickwork or sandstone | 40 |
| Compression.— | |
| Concrete 1:2:4 | 400 |
| Concrete 1:3:6 | 350 |

| (*c*). *Working Stresses in Reinforced Concrete*: | *lb. per sq. in.* |
|---|---|
| *Note*: Concrete to be 1:2:4 or richer mixture. | |
| Tension.— | |
| Steel reinforcement | 18,000 |
| Concrete | 0 |
| Compression.— | |
| Concrete: Extreme fibre of beams | 650 |
| Extreme fibre adjacent to support of continuous beams | 750 |

Shear and Diagonal Tension.—

Unit Shear $= v = \dfrac{V}{jd.b}$

Where $V$ = total shear.
$jd$ = effective depth of beam.
$b$ = breadth of beam.

| | |
|---|---|
| (*a*) Beams with horizontal bars only ... ... ... ... | 40 |
| (*b*) Beams with bent-up bars properly arranged ... | 60 |
| (*c*) Beams with web reinforcement designed, exclusive of bent-up bars, to resist two-thirds of vertical external shear ... ... ... ... ... | 120 |
| (*d*) Punching shear if all tension normal to the shearing plane is provided for by reinforcement ... ... | 120 |
| Bond, Concrete and Steel.— | |
| Plain rods ... ... ... ... ... ... | 80 |
| Drawn wire ... ... ... ... ... ... | 40 |

Modulus of Elasticity.—

Ratio, steel to concrete = 15 for design.
= 8 for calculating deflections.

(*d*) *Working Stresses in Timber* :

| Nature of Stress. | Ironbark. lb. sq. in. | Tallow-wood. Grey Gum, Grey Box. lb. sq. in. | Oregon. lb. sq. in. |
|---|---|---|---|
| Tensile ... ... | 2,200 | 1,800 | 1,000 |
| Compression.— | | | |
| $\frac{L}{D}$ less than 10 ... | 1,300 | 1,200 | 700 |
| $\frac{L}{D}$ from 10 to 24 ... | $1{,}500-\frac{20\,L}{D}$ | $1{,}400-\frac{20\,L}{D}$ | $800-\frac{10\,L}{D}$ |
| Across grain ... | — | — | 100 |
| Bending.— ... | | | |
| Extreme fibre ... | 2,200 | 1,800 | 1,000 |
| Shearing.— | | | |
| Selected timber ... | 240 | 180 | — |
| General ... ... | 200 | 150 | 100 |

(*e*) *Bearing Pressure on Masonry and Brickwork* : *lb. per sq. in.*

| | |
|---|---|
| Concrete 1:2:4 ... ... ... ... ... ... ... | 600 |
| Concrete 1:3:6 ... ... ... ... ... ... ... | 500 |

In designing bearings to carry the ends of two adjacent spans or for other similar cases where through partial loading the resultant pressure is not central on the bearing, the sum of the computed maximum bearing pressure due to bending moment reduced by 20 per cent. and the direct bearing pressure shall not exceed the amounts listed above.

(*f*) *Working Pressure on Foundations* : *lb. per sq. ft.*

| | |
|---|---|
| Solid sandstone ... ... ... ... ... ... | 60,000 |
| Compact gravel and hard shale ... ... ... ... | 20,000 |
| Hard deep clay interposed with shale and sandstone bands, soft rock ... ... ... ... ... | 12,000 |
| Soft shale ... ... ... ... ... | 6,000—10,000 |
| Clay, moist or mixed with sand or soil bands | 4,000—6,000 |

## APPENDIX "B."

### Contact Pressure Between Rollers and Track-Plates.

The rollers make initial contact at about 13½ in. from the track-plate end and carry full load—850 tons—at about 18 in. from end. The load per linear inch of effective track width as designed is 19.3 tons and to carry this the rollers will indent the plates and be slightly flattened, forming a definite contact surface, a cross section of which will be an arc whose ordinates from original track level will represent the distribution of above load, the central ordinate being 1½ times the mean. To determine the chord of this arc special tools were made consisting of fine feelers, 0.004 and 0.006 in thickness, attached to recessed ends of light steel bars, 18 in. and 24 in. long and 1 in. x ⅛ in. section. A pair of these was used in each case, the feelers being carefully inserted under the roller, opposite to each other, with bars square to axis and position of ends measured from scribed datum lines on the track plates parallel to axis. From the figures thus obtained, the distance between feeler ends could be simply deduced. An average value of $1\frac{13}{16}$ in. using 0.004 feelers each side, was adopted as the most reliable figure. Treating this as the chord of an 84 in. circle, the versed sine or central ordinate is 0.0098 in. and, deducting feeler thickness, 0.0058 in. is the height of contact arc which corresponds to a chord of 1⅜ in. (See Fig. *A*). The mean average pressure over contact surface, therefore, is 19.3 ÷ 1.375 = 14 tons per sq. in. and the maximum 21 tons. As the track-plate is more rigid over the webs than between them, the latter figure has been a little exceeded, probably, at those points.

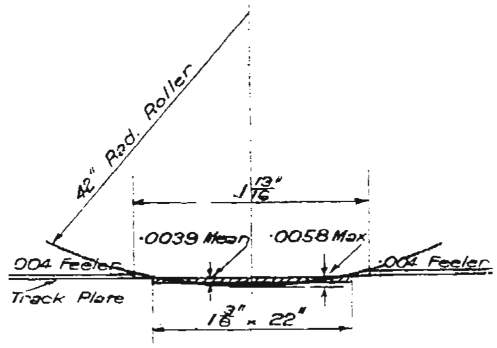



*Fig. A.*

As a result of such high stress, some flow of metal has occurred and produced the following effects: (*a*) a widening of each plate from $29\frac{11}{16}$ in. to $30\frac{1}{32}$ in. for a length of 11 ft., the portion traversed by roller under full load; (*b*) a depression of the edges of each plate for above length to the extent of ¼ in. at the outer and $\frac{9}{32}$ in. at the inner, diminishing to $\frac{3}{64}$ in. in a length of 4¾ in., the balance of width presenting a slightly convex surface; (*c*) the inner tyre only of each roller became displaced at one point an amount of $\frac{3}{32}$ in. This point was originally near the bottom but, owing to a slight increment of rotation at each opening, during which the roller makes a half rotation each way, it was, at time of initial observation, in the opposite position. Recent examination shows a slight increase in this value, particularly in the western roller. There is no evidence of lateral corrugation in the track-plates.

Owing to the hardening of the steel in track-plates, under this rolling action, the plastic flow has gradually diminished and it is anticipated that stability will shortly be reached. From experiments made with the Poldi testing appliance, the steel, where rolled, has increased in tensile strength from 34—36 tons per sq. in. to 39—42 tons, the former figures being obtained from portions of the plate not rolled. The roller tyres showed a tensile strength of 51—55 tons and no change is indicated.

Since the opening of the bridge for railway traffic, the bascule span had been operated 200 times up to 8:9:1932 and 47 times from the opening for vehicular traffic on 19:7:1932 to that date. The average number of openings per day for the whole period and the two portions thereof is, respectively, 1.65, 2.22 and 0.9. The last figure represents normal conditions, as in the earlier period a number of openings was made for testing and for adjustment of gear and weights.

### Power and Speed Observations.

Figure B gives diagrams of power and current readings on a time basis and speed of operation in opening and closing the main leaf. An indicating watt-meter, a recording ammeter (10 in. approximately per minute) and two stop-watches were employed.

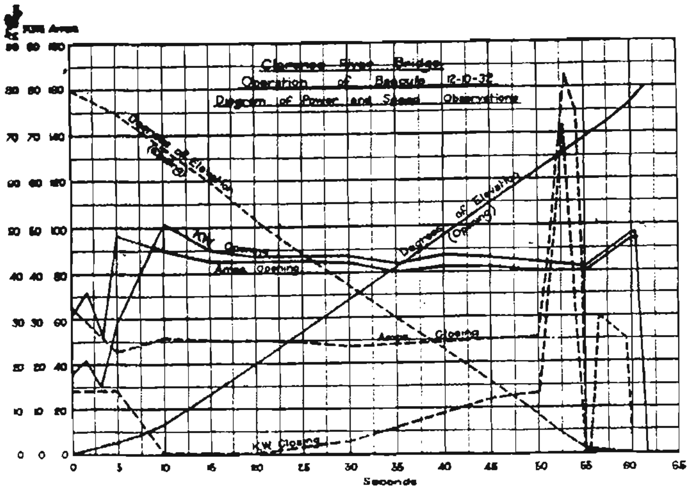



*Fig. B.*

The current chart revealed a continuous oscillation of amperage, the frequency being about 1.8 per second and the amplitude, for the major part of the opening, 40 to 50 amperes; the frequency during closing was the same but the amplitude, for the most part, small and varying with the power demand. The oscillations practically tally with the meshing of the rack-teeth and indicate a vibration of the span in the vertical plane. In the diagram a mean current reading is taken throughout. The observations, which were made by Mr. Twigg, are for a calm day, but previous power readings on days with strong south-easterly and westerly breezes show, in the former case, 25% increase, and in the latter, 20% decrease, only partly due to wind, during the upper portion of the opening but practically no change in the closing operation. Early in May, when the span was not so well balanced, experiments were made, consecutively, with two motors and one motor operating. The only difference recorded was in time, the latter taking five seconds longer to raise the span. In an emergency, therefore, one motor can be relied on to carry on the duty.

In regard to the minor operations, the gates, in unison, take 16 seconds, the hinged road leaf 11 seconds, the rail lift 10 seconds and the lock 10 seconds, measurement in each case being from pressing of button to flash of indicating light. The total time of operation from flashing of yellow acknowledgment signal to flashing of green all-clear signal was found under normal conditions to be 146 seconds, the sequence being as set out in Appendix C.

## APPENDIX "C."

### Operating the Bascule Span.

The sequence of operations will be, normally, as follows:—

(1). Master of vessel sounds three long blasts on whistle or siren.
(2). Bridge operator, if on duty elsewhere, proceeds to intermediate staff instrument on lower deck at bridge.
(3). Telephones signalman at South Grafton who consults signalman at Grafton. If both satisfied, operator is informed by one long ring on the telephone.
(4). Lifts staff into the head of the instrument.
(5). Pulls the lever that unlocks the rail lift.
(6). Proceeds by stairway to cabin and closes switch that controls the six masthead lights.
(7). Closes main oil circuit breaker.
(8). Switches on acknowledgment light (yellow).
(9). Switches on gongs and the lights that illuminate these and the warning notices.
(10). Inspects portion of roadway and of each footway between gate stiles.
(11). Closes northern and southern gates and shuts off gongs and lights.
(12). Inspects, as before, for trapped vehicles or pedestrians.
(13). Opens hinged road leaf.
(14). Opens rail lift.
(15). Opens bridge lock.

*Note*: Button switches used for operations 11—15.

(16). Places the master (or emergency) brake switch in "off" position, depresses emergency control button and moves controller handle in "open" direction to extreme position.
(17). When span is fully open (indicating light green), releases emergency button, restores controller handle to neutral position and places master brake switch in "on" position.
(18). Shows green signal light at masthead to waiting vessel. Opposite light shows red.
(19). Reverses signal lights if a vessel is also waiting in the contrary direction.
(20). Places master brake switch in "off" position, depresses emergency control button and moves controller handle in "close" direction. Limit switch will cut off all power when span is nearly closed.
(21). Restores handle to neutral position, depresses pedal switch and moves controller handle to second or third notch in "close" direction, back to second notch to check speed when necessary. When indicating light shows white, operation is complete.
(22). Releases emergency control button, restores handle to neutral position and places master brake switch in "on" position.
(23) to (27). As for (15) to (11), but presses the "reverse" button.
(28). Opens the main oil circuit breaker.
(29). Opens switch controlling signal lights for vessels.
(30). Puts back lever locking rail lift, thus cutting off power from the cabin. This operation is not required if span is to be opened again before next train is due.

[*Part II—Construction, will be published in the next issue of* The Journal.]

# Addresses Wanted.

Members able to give any information regarding the present addresses of the following members are requested to forward such information to Headquarters, Science House, Gloucester and Essex Streets, Sydney.

| *Name.* | *Last Known Address.* | *Div.* |
|---|---|---|
| Allan, C. J., Stud. | Associated General Electric Supplies Co., Atcherley House Queen and Adelaide Sts., Brisbane | S. |
| Ferguson, G. L., Jr. | North Australian Commission, Darwin, N.T. | S. |
| Francey, R. M., A.M. | Messrs. Francey & Paton, 19 O'Connell St., Sydney | S. |
| Houghton, G. G., A.M. | 8 Orpington St., Ashfield | S. |
| Johnston, G. A. S., A.M. | 43 Patrick St., Hurstville | S. |
| Lee, F. S., A.M. | Daking House, Rawson Place, Sydney | S. |
| Liebert, S. F., A.M. | 23 Darley Rd., Randwick | S. |
| McPhail, J. M., Stud. | 65 Victoria St., New Lambton, Newcastle | S. |
| Mountain, J. K., A.M. | Yorkshire House, Spring St., Sydney | S. |
| Phelps, C. J., Jr. | Public Works Department, Bridge St., Sydney | S. |
| Wilks, H. W., A.M. | No. 2, Dunsbury Flat, 59 Shadforth St., Mosman | S. |
| Williams, C. L., Jr. | N.S.W. Government Railways, Bridge St., Sydney | S. |

# TRANSACTIONS OF THE INSTITUTION

# The Clarence River Bridge.

## PART II.—CONSTRUCTION.

By JAMES WALLER ROBERTS, B.E.

*Associate Member.**

### TENDERS AND CONTRACTS.

On 17th March, 1926, lump sum tenders were invited for the carrying out of the whole work in the bridge proper, comprising the seven river piers, the five fixed 240 ft. truss spans, the bascule span with operating machinery and electrical control equipment, the two 66 ft. deck plate girder railway spans, down track only, the two 100 ft, skew truss roadway approach spans and the four ramped truss footway access spans. The Railway Department was to carry out the balance of the railway, roadway and footway approaches, including the shore piers, lay the whole of the permanent way, provide power to the switchboard in the operating cabin and submarine cables between the piers supporting the bascule span. Forty-one drawings were involved in the contract and a period of three years was allowed for the completion of the work. The specification provided that the whole of the metalwork, excepting special machine parts, was to be fabricated in Australia and that the material used was to be rolled, cast or otherwise manufactured in Australia, if of a size obtainable therein, but if imported not to be drilled or machined abroad. All metal work to be in accordance with the latest British or Australian standard specifications, as the case required.

On the closing date, 26th May, 1926, two tenders were received, the lower being from Dorman, Long and Company Limited, who submitted an amount of £484,190. As this was considerably in excess of the departmental estimate, it could not be recommended for acceptance. An analysis of the tender showed that the primary difference lay in the section dealing with the substructure. It was obvious that the tenderers had provided a considerable margin to secure themselves from loss of plant and material, in the case of floods and freshes, or arising from errors in the boring data, or from disposal of plant at the close of the work. Should such contingencies not materialize, or only in a minor way, the firm would benefit but the State would have to pay whatever the outcome. This indicated that it would be advisable for the department itself to undertake the more hazardous part of the work, such as the construction of the piers and the erection of the superstructure, and submit the manufacture and supply of the metal work, only, to tenders and of such plant as could not be otherwise obtained. This course was approved and the final result has justified the step that was taken. Owing to financial difficulties, however, action in this direction was delayed and it was fully a year before the matter was again in progress.

On 15th June, 1927, tenders were invited for the manufacture of metalwork in the six permanent and six temporary steel caissons, closing 17th August, and on 7th September the tender of the Clyde Engineering Company Limited, was accepted for an amount of £21,674. Delivery was arranged on a time schedule to synchronize with the anticipated progress of the work in the field, the total period being sixty-five weeks. On 31st August of this year tenders for the manufacture and supply of the superstructure of the bridge, covering the spans previously detailed, were invited, closing 30th November, 1927, and the Clyde Engineering Company Limited was given this contract also, on 14th December, 1927, the amount being £144,213. Delivery was again arranged on a carefully considered schedule commencing in forty-two weeks and covering a total period of one hundred and forty-three weeks, the southern approach spans being first required and the sequence of subsequent deliveries being from the southern to the northern end of the bridge. For convenience of reference, the five main truss spans were designated by the letters *A* to *E* in the above order. Spans *A* and *B* adjoining the bascule span had ends modified in consequence, *A* considerably, *B* only slightly so. Spans *C*, *D* and *E* were interchangeable in all respects. The Australian General Electric Company Limited had the sub-contract for the supply of electrical machinery and magnetic control equipment for the operation of the moving leaf and the five other subsidiary movements associated therewith.

The specification provided for the temporary erection, in the manufacturer's yard, of each separate span of different type, the two panels of *B* span only being required in this way. This enabled clearances to be examined and revised where needed and erecting plans prepared showing the reference marks on the various members, which facilitated re-erection at the site. A maintenance period of six months for the mechanical and electrical work was also specified, dating from the first opening of the bascule span under traffic conditions.

### PLANT CONTRACTS.

A considerable amount of both floating and fixed plant was required for a work of this magnitude and was not available. Designs were prepared for several different types of punts and tenders invited for their construction. Three of these were 53 ft. x 18 ft. 6 in. x 4 ft. 7 in. overall of which two were primarily for the location of the guide piles at the pier sites required for the construction and lowering of the permanent caissons to their foundation level, and all were serviceable for the subsequent conveyance of materials to these sites. Two of them, 89 ft. x 30 ft. 10 in. x 6 ft. 6 in., were utilized for the carrying of plant, one for the electrically-driven concrete mixers and derricks for handling and placing the output in the caissons and forms, and one for the steam-driven air compressor plants for the

**Continued from The Journal, Vol. 4, No. 11, November, 1932. p. 381.*

pneumatic sinking process. A punt to carry shear legs of 10-ton capacity with steam boiler and winch, 69 ft. 8 in. x 35 ft. x 6ft. 6 in., was also constructed. These six punts were built under contract, by Allen Taylor and Company Limited on a river site in the Grafton station yard. Two further punts were built at the same site by this firm for the primary purpose of floating out the steel truss spans after erection on the grillage. These measured 90 ft. x 30 ft. x 8 ft. 1 in. overall and the hull was subdivided by two longitudinal and one central cross bulkhead into six practically watertight compartments. Galvanized iron pipes, 6 in. diameter, fitted with gate valves, gave each of these access to water through the punt's side so that, when required, each punt could be submerged to any extent, being subsequently pumped out by a powerful 7 in. steam-driven centrifugal pump capable of delivering 220 gallons per minute against a 20 ft. head. Three other punts were purchased, one locally and two from Woodley's Ltd., Sydney. The punts built under contract were constructed, originally, of Oregon decks and sides and green turpentine bottoms, following standard Sydney Harbour practice. The sides for a height of 3 ft to 6 ft., according to punt depth, and 6 in. to 8 in. of the bottom were covered with tarred ship felt and sheathed with No. 24 gauge galvanized sheet iron. For the marine borer inhabiting the brackish water of the Clarence River, however, green turpentine has no terrors and, after nine or twelve months in the water, it was found necessary to dock the punts and renew the bottom timbers using Oregon sheathed, as described above. The internal framing of all punts, except those for flotation purposes, was of approved hardwood but in the latter Oregon was used for frames and bulkheads, to gain lightness, with ti-tree crooks for the keelson ends, as in the other punts.

The Clarence River County Council's southern transmission line, carrying a 6,600 volt three-phase fifty-cycle current, passes over the South Grafton station yard in close proximity to the end of the bridge. Advantage was taken of this to introduce a considerable amount of electrically-operated plant. Arrangements were made for a pole substation and a transformer of 100 kilowatt capacity was installed to convert the current to 415 volts. Tenders were invited and contracts let for two five-ton derrick cranes, W. A. Hodkinson & Co. Ltd., two thirty-cwt. winches and one ten-ton travelling gantry crane, Noyes Bros. (Sydney) Ltd. These were all fully equipped with limit switches and solenoid brakes for safe working. The derrick cranes were installed at the depot in the South Grafton yard, one on the jetty for loading punts from trucks and the other near the intersection of two delivery sidings for handling steelwork required on the grillage but placed for a time in storage. The cranes had hoisting, slewing and derricking gear operated by one 17½ h.p. motor and could hoist 5 tons at 30 ft. per minute at a radius of 60 ft. Sleepers and backstays were of timber supplied by the department. The winches were placed on two of the large punts and used for hoisting concrete into the caissons or pier forms. Separate drums were provided for hoisting, slewing and derricking, operated by a single 10 h.p. motor. The timber mast, jib, backstays and all ropes and tackle were supplied and erected by the department. The concrete was mixed by electrically-operated 10 h.p. machines of 15 c. ft. capacity, with power loaders and automatic cisterns. The gantry crane, Fig. 9, was designed for the erection of the 240 ft. truss spans on the grillage. The " A " shaped side frames, through which loaded trucks could pass, were built 40 ft. apart and each travelled on 80-lb. runway rails on a carriage of two pairs of wheels in tandem, spaced 30 ft. 7 in. centres. There was a clearance of 50 ft. from rail level to the overhead girders carrying the crab with its hoisting and traversing gear and motors. The motor supplying the travelling power was placed centrally on these girders and operated through horizontal and vertical shafting with bevel gears. The capacity of the respective motors was as follows :— Hoisting, 10 tons at 15 ft. per minute, 5 tons at 30 ft. per minute, 17½ h.p.; traversing 80 ft. per minute, 5 h.p.; travelling 150 ft. per minute, 15 h.p.; speed from 700 to 715 r.p.m. Current was collected by a specially shaped arm from three safely housed conductors carried on the side of the longitudinal timber which supported the rail on the shore side of the grillage.


*Fig. 9.—Depot Site : Layout of Construction Buildings, Sidings and Plant.*

### Deviation of Route.

During 1926, an amended railway route through the City of Grafton, shown in Fig. 1 of Part I. of the paper, was considered and surveyed and finally approved by the Railway Commissioners in September. This did not affect the site of the bridge but eliminated the proposed new station near Mary Street, utilized the existing station at Grafton, shortened the construction length by three-quarters of a mile, provided square crossings at most of the principal streets and reduced resumption costs.

### Field Work.

*Construction Depot.*—In August, 1927, Mr. S. D. Webb took up duties at South Grafton as resident engineer and initiated the preliminary operations. The portion of the South Grafton railway yard adjoining the river made a satisfactory site for the layout of the necessary buildings, sidings and plant, being fairly level, above ordinary flood

level, accessible to railway, road and water, and adjacent to the bulk of the new work, as indicated in Fig. 1 of Part I. An immediate start was made on the various buildings, office, cement store, general store and machine shop, quotations obtained for piles and pile driving, and a 40 ft. pile driver built. All piles required for river work were specified to be turpentine with the bark intact but, as in the case of punt bottoms, the *teredo* proved highly destructive and, although the caisson guide piles lasted the necessary time, those used in the grillage, which was needed for several years, had to be successively protected by a surround of concrete and in the end only a few were not so treated. It is noted, as a curious fact, that the attacks commenced in the deep water and gradually proceeded towards the shore.

The grillage was 300 ft. x 43 ft. overall, carried on eighty-one piles, about 18 in. mean diameter, arranged generally in 30 ft. bays with steel longitudinal girders and hardwood cross beams, planked where necessary for getting about. Two docks wide enough to easily accommodate flotation punts were provided, also bridged by steel girders.

With the exception of four broad flange beams, 40 in. x 12 in., taken from stock, and required to carry the assembled span over the punt docks, which were 37 ft. 4 in. wide centre to centre of piles, all the steel girders used were temporarily borrowed from the permanent work. Those bridging the docks, except the pair carrying the back rail and conductor wires, were arranged to afford easy removal and replacement each time a span was floated out. The general deck level of the grillage was about 23 ft. above mean high water. Beyond the upstream end, leaving space for a punt, a jetty 120 ft. x 20 ft., with deck 20 ft. above mean high water, was constructed on which a siding was laid from the existing coal siding and a five-ton electric crane installed. This was used for loading caisson steelwork into punts and all steelwork for superstructures not erected on the grillage, such as the bascule span, counterweights and fixed span *E* and also for general loading in the way of timber, cement, fuel, etc. A branch siding into the yard enabled timber, steel bars and general stores to be delivered. A siding was also laid on to the downstream end of the grillage from the railway wharf line

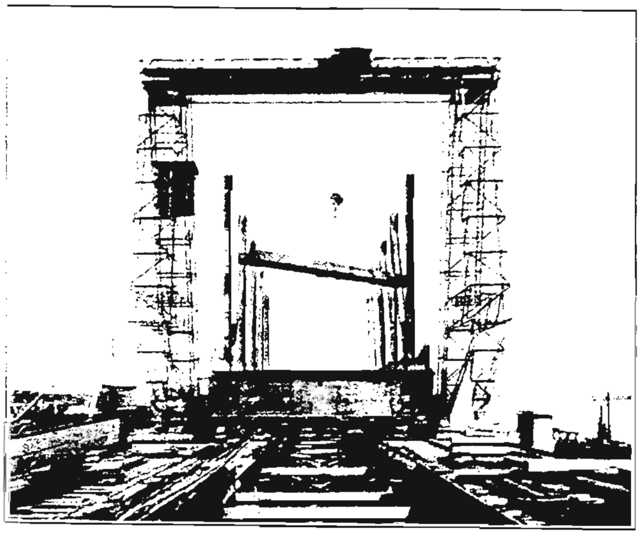


Fig. 10.—*Grillage and Gantry Crane—Assembly of Superstructure.*

and used to convey superstructure steelwork for erection on the grillage where it was handled by the gantry crane. If not immediately required, it was unloaded from trucks by the five-ton electric crane installed in the yard and stacked in the storage space, tracks being laid to various points of the yard so as to utilize all available room. The general layout of the depot, showing above features, also the southern base line, substation, power lines and submarine cables, is indicated on Fig. 10. The cable was laid in separate lengths from pier to pier terminating at each position in a junction box placed on a pile, or extension therefrom, at a height of about 12 ft. above high water level so as to be clear of freshes and floods. Leads thence were carried in conduits to the various machines and lights, current for the latter being stepped down to 25 volts for safety. By June, 1928, the depot arrangements were well advanced and power was switched on to the mains.

*Pier No.* 1 on the southern bank of the river, being accessible by land, was the first to be constructed and excavation proceeded under cover of a timber coffer dam. Progress was delayed at the outset by minor floods but, eventually, after passing through bands of clay, slate and soft sandstone, a hard and sound sandstone was reached at 29 ft. below the surface. A test bore, 13 ft. deep in the bottom, failed to discover any weakness and the pier was founded at this level. The river bed on the channel side was subsequently dredged out to permit access by the flotation punt in its final shift for the erection of span *A*. Scour on this side of the river is still in evidence, due to the concave curvature of the bank and the pier is now in contact with the river.

*Guide piles* for the support and control of the caissons during assembly, riveting and sinking, were located by means of the small punts previously referred to which, with suitable outrigger framing, formed a template for the driving of each pile in its proper place. The punt was moved into practically correct position at each pier site by means of hand winches at the four corners hauling on anchored cables lying diagonally to the centre line of bridge. Four anchors, weighing from 12 cwt. to 20 cwt. each, were dropped into approximate position in the river by means of sighters on shore. Instrumental readings at the ends of the base line enabled the final location of punt to be determined and, after piles were driven and punts removed, reference marks were established on the staging and checked from time to time enabling the caisson to be kept truly to position.

Each group of piles consisted of sixteen driven vertically and eight to a batter, each of the latter being bolted to its vertical neighbour. The staging was cantilevered at each end to carry hand and steam winches and boilers for subsequent operations. Piles in pier No. 2 were driven to rock, 9 to 13 ft. below river bed and elsewhere as required for stability. The addition of walings and bracing made a firm structure. The piles were of turpentine, with bark intact, but the marine borer, in time, practically destroyed them though not until they had served their purpose.

A motor launch of 5 tons register was purchased for transport of staff and men across the river and to the various construction points thereon.

A *gravel deposit* of excellent character for concrete, hard and siliceous, was discovered 20 miles up the river, covering an area of about 50 acres to a maximum height above high water of about 25 ft. The proportion of sand was found to be satisfactory and countless rains and freshes had washed the material clean. Large stones were plentiful

those over 4 inch gauge, approximately, being reserved for the crusher, or used as " plums " in the concrete mass of the piers. Jubilee wagons, running on portable tracks, 2 ft. gauge, were utilized to convey the gravel, which was hand-shovelled, to the jetty which was so constructed as to enable a punt to lie beneath and receive the material as it was tipped. By moving the punt fore and aft, the load was evenly distributed and, with the assistance of coamings, from 80 to 100 c. yds. could be transported on the large, and 40 c. yd. on the small punts, the trip to and from the deposit taking a day. A tug was chartered for towing purposes. Gravel for crushing was taken to the old wharf in Grafton yard where a crane operating a Priestman grab was installed which transferred the material into a timber bin with hinged door, whence it could be loaded into lorries and taken to the crusher and screening plant at Kent Street near the northern approach. Gravel for concrete piers was not crushed but used as it came from the deposit.

*Caisson Sinking.*—Large caissons are usually built near a river bank on slipways, launched on cradles, completed in adjacent docks and then floated to the pier site. This course was originally contemplated and tentative designs were prepared.

A study of the problem on the ground indicated difficulties chief of them being lack of space for satisfactory working at the selected site; see Fig. 10. No other site possessed the same general facilities. It was ultimately decided to adopt, in a modified way, the method that had been successfully used for many years in pier construction with concrete cylinders. These were moulded to required height to reach the river bed on a movable staging, which could be lowered when the concrete had seasoned, and further lengths added as required to reach the foundation level. Heavier plant was required to handle the caissons but, as an offset, only sufficient section needed to be built and lowered as would float and carry the next section with a reasonable margin of free-board. The working chamber with roof girders and the next tier of plates forming the shell, giving an overall depth of 12 ft. 9 in., was adopted as the launching unit; see Fig. 3 in Part I. The weight of this, with supporting staging, tackle, etc., was estimated to be, approximately, 80 tons and, to carry and lower this load, four five-ton hand winches were installed on the fixed pile staging at points adjoining the caisson corners. A single wire rope was taken from a winch barrel, reeved through three vertical pairs of double and treble sheave blocks and finished off on the opposite winch barrel on the long side, each upper block being fixed to the pile headstock and the lower to the movable floor on which the caisson material was assembled, riveted and caulked. The other pair of winches was similarly connected. As a result, when the load was carried the pull on the rope did not exceed about $2\frac{3}{4}$ tons and the operation was under complete control. The caisson material was handled by one of the 80 ft. shear legs mounted on a punt, with steam winch and boiler. A certain amount of concrete was placed in the " V " shaped pocket above the cutting edge, before lowering, to ensure water tightness.

The launched section, with air shafts in place, freed from timber and tackle, floated with about 5 ft. of free-board. The bottom 8 ft. of caisson displaced about 76 tons of water and each subsequent foot about 30 tons. As each section was added, 4 ft. 9 in. deep, weighing about 14 tons, concrete was placed in the shell, enclosing the air shafts, in sufficient quantity to bring the top in position for next assembly. This concrete consisted of six parts of gravel and sand to one part of cement. To submerge the whole caisson to within a foot of the top required 300 c. yd. of concrete, weighing about 500 tons, and a section of temporary caisson was now provided. Tomming, of course, was essential to stay the shell against hydrostatic pressure and old rails to a small extent and timber, round and square, in general, were used for the purpose, the rails being left in and the timber shifted as the concrete filling reached the level occupied.

In the case of pier No. 2, which was the first in which this method was adopted, it took another 300 c. yd. of concrete to bring the cutting edge to the firm bed of the river about 44 ft. below mean high water and at this stage four temporary caissons and six pairs of air shafts had been bolted to the permanent caisson.

*Air locks* had now to be fixed to the top of the air shafts before further sinking could be carried out and two types were used, a third type being available, if required. The old departmental lock used throughout the north coast railway, and pre-dating that, was again brought into requisition, thoroughly tested, strengthened and equipped with electric light, telephone, air mains, pressure gauges, etc.

The main chamber of this lock is 8 ft. diameter by 6 ft. high and the compression chamber 3 ft. 1 in. wide by 3 ft. 7 in. long, with rounded end, and 5 ft. 3 in. high. It possesses two outlet chutes for disposal of excavated spoil and one inlet chute for concrete and the air supply main was provided with non-return values to safeguard the men in case of breakage. It was used occasionally for transfer of men to and from the caisson. The men travelled by bucket, ladders being omitted as they were considered liable to trip the bucket. The hoisting rope for the bucket passed through a gland in the dome, and round a sheave to a steam winch carried on the staging.

The other lock, hired from the Queensland Railway Department, had a main chamber 5 ft. diameter by 7 ft. 3 in. high and a compression chamber 3 ft. 6 in. diameter by 5 ft. 9 in. high and was similarly equipped. It had attached to it, on the outside, an air cylinder, with piston 18 in. diameter, 4 ft. 6 in. stroke, double acting, with rack spindle and gear for operating the bucket hoist, but it was found to be unsuitable for the depth of shaft to be worked and was not used. This lock was reserved for the transfer of the caisson workers only, who descended and ascended by the steel ladders provided.

The usual number of men in a caisson shift, excluding the sub-foreman, was five, three men shovelling and one man wheeling buckets in the chamber and a man in the material lock handling buckets and operating the lock and chute doors. During the operation of sealing the foundation with concrete an extra hand was taken on. The compression chamber in the departmental lock could accommodate four and in the Queensland lock two men. At the outset four shifts per day of 24 hours were employed but, after the second caisson was sunk, there was a reduction to two of six hours each until the increase of pressure necessitated reduction to four hours, when four shifts were again employed. In pier No. 6 there were, for a short period, three shifts at work during the six-hour stage.

The hours of work and the periods of compression and decompression were in accordance with an industrial award, for cylinder employees working under air pressure, as given in Table I.

TABLE I.

| Gauge Pressure lb. | Compression minutes | Work hours | Decompression minutes |
|---|---|---|---|
| 0-20 inclusive | 10 | Up to 6 | 15 |
| 21-26 inclusive | 12 | Up to 6 | 20 |
| 27-30 inclusive | 15 | Up to 4 | 31 |
| 31-32 inclusive | 15 | Up to 4 | 36 |
| 33-35 inclusive | 17 | Up to 3 | 38 |

The minimum time allowed between shifts was 8 hours.

Pay under this award was 21s. 3d. per shift, reduced in January, 1930, to 21s. Men had to obtain a certificate of fitness from medical officer before entering lock. On emerging they had use of dressing-room, hot water, shower-baths and a coffee urn but supplied their own coffee. No case of serious sickness was reported, the maximum pressure reached being 35 lb. per sq. in. but only occasionally.

The air locks were fitted to the 3 ft. diameter shafts by means of matching pieces. All bolted joints were sealed with shaped rubber packing, ½ in. thick in general, but 1 in. thick for outside chute doors and between matching piece and the main chamber on one side and the shaft flange on the other. The total weight of the large air lock in use was 12 tons. A steam-driven air compressor was used, in duplicate, for the air supply as a matter of safety owing to the possibility, though remote, of a breakdown in current supply if electric power had been adopted.

Experience showed that the air-holes left in the cutting edge were more disadvantageous than otherwise as the water could not be expelled below this level and the men had to handle sloppy material while working on a wet base. They were accordingly plugged up and the air allowed to escape from under the cutting edge, as in the case of cylinders. Spoil buckets were moved to and from the material shaft, to reach remote parts of the chamber, by trollies running on portable tram lines, two in the large and one in the small caissons. It took four buckets to fill a chute which held practically a cubic yard.

Table II. gives some details of sinking in the six piers in which caissons were employed.

TABLE II.

| Pier No. | Shifts worked per 24 hours | Work hours | Qty. excavated c. yd. | Man-hr. worked under air pressure | Man-hr. worked at surface | Quantity handled per man per hr.: Excav. only c. yd. | Quantity handled per man per hr.: Excav. and handlg. c. yd. |
|---|---|---|---|---|---|---|---|
| 2 | 4 | 6 | 390 | 1,032 | 720 | 0.38 | 0.22 |
| 3 | 4 | 6 | 830 | 1,181 | 768 | 0.70 | 0.42 |
| 4 | 2 | 6 | 1,183 | 1,032 | 684 | 1.15 | 0.69 |
| 5 | { 2<br>4 | 6<br>4 } | 1,214 | 1,380 | 936 | 0.88 | 0.52 |
| 6 | { 2-3<br>4 | 6<br>4 } | 1,551 | 1,308 | 936 | 1.19 | 0.69 |
| 7 | { 2<br>4 | 6<br>4 } | 1,808 | 2,372 | 1,120 | 0.76 | 0.52 |
| | | | 6,976 | 8,305 | 5,164 | 0.84 av. | 0.52 av. |

The hours were shortened from six to four when pressure exceeded 26 lb. per sq. in.

Two eight-hour shifts were worked on the surface hauling and handling the spoil from chute to punt. The comparatively low value in pier No. 2 was due to men being new to the work, the large percentage of rock and the outbreak of three springs in the bottom, calling for special measures. Pier No. 5 had a fair period of high pressure and a badly crevassed bottom requiring channelling and gad work to ensure good seating. Piers Nos. 4 and 6 passed through material easily excavated. Heavy material was encountered in pier No. 7 and four men were employed shovelling; bottom was difficult, timber met with and a high pressure needed over a fairly long period.

*Air circulation* was maintained by the passage of air from the compressor through valve-controlled leads into each lock and a release valve in the pipe from small lock. Normally, there would be sufficient air escaping from the working chamber and locks to promote circulation but, when this was insufficient for comfort, the release valve was set slightly open, the entry valve in the small lock closed and air would then flow through the large lock, down the material shaft, through the chamber, up the man shaft and out. By closing both entry valves and opening release to full extent, a sudden fall of pressure would occur which would help to sink the caisson.

*Sealing* of the working chamber under air pressure was accomplished by depositing four to one concrete in 12 in. layers to a thickness of 3 ft. over the whole area of the floor. Considerable heat was developed during this operation, making conditions very unpleasant for the workers as the escape of air was too slow. When sealing piers Nos. 4, 5, 6 and 7, a pair of 2 in. diameter galvanized iron pipes was introduced at each end of the caisson with right-angle bends under the cutting edge, thus enabling air to escape freely and keeping the chamber reasonably cool. After the sealing layer was complete and the pipes plugged, seventy-two hours were allowed to elapse under pressure and air then gradually released.

*Filling* of the working chamber proved a somewhat difficult task and was carried out in this manner :—A wall of concrete in bags was built across the chamber, about 5 ft. from each end and the space behind filled up with a moist concrete, six to one, well packed, to within 6 in. of the roof. After shrinkage had taken place, a fairly dry concrete was placed in this recess and thoroughly rammed. The process was repeated at the ends and in the middle section till the chamber was well filled with compact concrete, the portions under the shafts completed the work.

*Temporary caissons* were made water-tight at all bolted joints by means of rubber packing, ½ in. thick in the horizontal and $\frac{1}{16}$ in. thick in the vertical joints. A considerable amount of tomming was required for which round and square timber was used. The pier was shaped inside these caissons with timber forming and as the level of concrete filling rose the long toms above were replaced by short toms off the forming, the concrete being given twenty-four hours to set before pressure was applied. When the top of the filling was well above high water level, a diver unbolted each section. It was found feasible to transfer the complete rectangular steel unit, 9 ft. deep, weighing 16 tons, from one pier to another using two pairs of punt-mounted shear legs in concert, thus reducing the diver's work very considerably. Fig. 11 shows the sequence of transfers of temporary caisson units and their gradual absorption in the work as the depth from river bed to foundation level increased. Only one unit ultimately survived and was found useful for cutting up when any plate or angle bar was required for temporary or even permanent service.

*Piers Nos. 6 and 7.*—Four caissons, three large and one small, were sunk and piers built in the manner described above, including piers Nos. 2 to 5. A departure was made in the case of pier No. 7 on the northern bank of the river. Piles were driven, as before, but were used for control only and not for support of the caisson, small size, which was built on the ground itself after due preparation. Air locks were provided, as before, and the caisson sunk for the greater portion of its height and filled with concrete to within 6 ft. of the top. Forms were then constructed over this, en-

closing the steel shell, and concrete poured to form three rectangular cells with walls 3 ft. thick at ends, 2 ft. thick at sides and 5 ft. thick in intermediate cross walls surrounding the two 3 ft. diameter air shafts. These were carried up to within a few feet of the surface and filled in with concrete, as required, to sink the caisson which was carried down to a foundation about 62 ft. below mean high water and sealed in the usual way. A good quality clean sand was passed through which was put on one side and used in the work. The upper part of the pier was shaped to accord with the others. This method proved satisfactory and economical.

In pier No. 6, this construction was also adopted for a portion of the pier adjacent to the permanent caisson but the upper part of the pier was formed inside two temporary caissons which were attached to the top of the walling described above. See Fig. 11.

Table III. gives a summary of details in regard to the seven river piers.

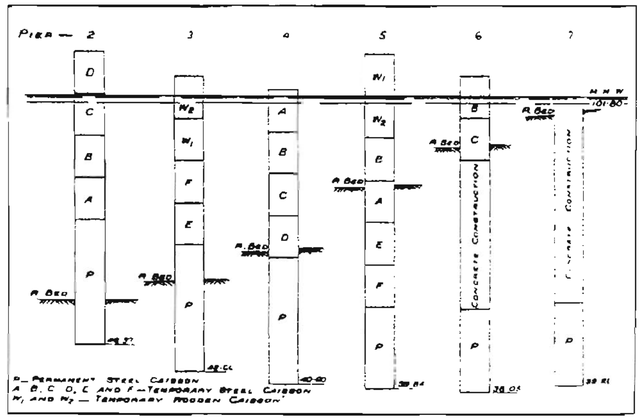


*Fig. 11.—Diagram showing Transfer of Temporary Caissons.*

TABLE III.

| No. | Depth of water ft. | Depth of excavation ft. | Height of pier ft. | Area of base sq. ft. | Concrete in pier c. yd. | Estimated weight of pier tons. |
|---|---|---|---|---|---|---|
| 1 | nil | 29 | 48 | 750 | 1,023 | 1,850 |
| 2 | 44 | 9 | 75 | 1,110 | 2,003 | 3,620 |
| 3 | 40 | 19 | 81 | 1,100 | 2,131 | 3,855 |
| 4 | 33 | 28 | 83 | 1,100 | 2,409 | 4,365 |
| 5 | 19 | 43 | 84 | 750 | 2,035 | 3,680 |
| 6 | 11 | 53 | 86 | 750 | 2,077 | 3,755 |
| 7 | 1 | 61 | 84 | 750 | 2,126 | 3,845 |

The mean average pressure in tons per sq. ft. on the base for 100 lb. road and 50 lb. footway load and *E*50 load on two tracks is as follows:—Piers No. 1, 4.6; No. 2, 5.5; No. 3, 4.9; No. 4, 6.0; No. 5, 7.1; No. 6, 7.1; No. 7, 6.2. Under certain conditions of wind, tractive force and flood maximum edge stresses on bases of Nos. 2, 3 and, possibly, 4 might reach 12 tons per sq. ft. when both railway tracks are in use, a very remote event at present. The depth to which piers Nos. 5, 6 and 7 are sunk in firm material makes it unlikely that, in these cases, the stresses on the base will ever be materially increased by lateral loads.

*Flotation of Spans.*—Before the grillage scheme of erection was adopted, alternative methods were considered. Falsework in the river was considered undesirable on account of liability to flood damage and for *A* span, moreover, there was very little holding depth for piles. Actually, as many piles were used in the grillage as would have been required for the five fixed spans but the grouping of them in a limited space, as in the former case, was a more economical undertaking and the structure being parallel, lengthways, to currents and freshes and not broadside on, as in falsework, was another factor in its favour. A method of end launching was also considered in which the grillage would be built square to the shore line, mostly over land, and the span moved out, when riveted, with one end supported on a punt and the other on a carriage riding on a specially prepared track till over the water when a second punt would take up the load and flotation then proceed as before. There was an element of risk in this which made it a somewhat doubtful proposition but, apart from that,

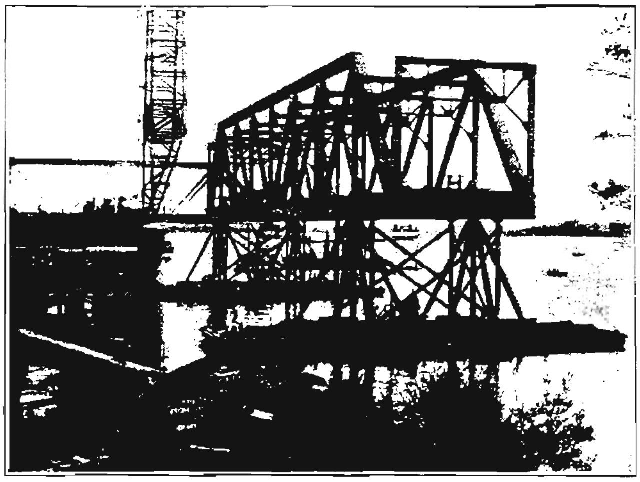


*Fig. 12.—Flotation of Fixed Span "B."*

it was, as estimated, more expensive and it was accordingly rejected.

An investigation was made of the *stability* of the flotation punt or pontoon during the transfer of the span to its permanent bearings and of the tidal effect on the most suitable time for operation and its duration. A floating span, on account of the high position and extent of the visible mass, gives a deceptive appearance of instability. The ensuing figures and diagrams, Fig. 13, show that there is quite a large margin of safety in the undertaking. The loads computed to be carried were as follows:—

| | |
|---|---|
| Weight of half steel span ... ... ... | 240 tons. |
| Weight of Oregon staging ... ... ... | 9 tons. |
| Weight of hardwood bearers ... ... ... | 31 tons. |
| Weight of machinery ... ... ... ... | 10 tons. |
| Weight of punt ... ... ... ... ... | 96 tons. |
| Total ... ... | 386 tons. |

The centre of gravity of each of these components was determined and that of the whole floating mass. The punt is 8 ft. 1 in. deep at the centre and has a longitudinal sheer of 4 in. It was computed that it would float under above load with a freeboard of 2 ft. at the centre and this was approximately the case. It was assumed that, under some horizontal or vertical load due to wind or wave, the punt careened over till there was only 6 in. of freeboard on the low side. This corresponded to an angular movement of 2° 21′. The centre of gravity was displaced 1.22 ft. from the

vertical plane through the original centre of buoyancy. A wedge of water weighing approximately 33 tons was displaced on the one side of this centre and a similar wedge emerged on the other side, the distance between gravity centres being 58.8 ft.

The conditions of equilibrium can now be expressed using the ton and foot as units :—

Stabilizing moment $= 33 \times 58.8 - 386 \times 1.22$
$= 1{,}940 - 471 = 1{,}469.$
= overturning moment $= W \times 44.9$ for a uniform wind pressure acting at the centre of exposed surface in the span.
Hence $W = 1{,}469 \div 44.9 = 32.7$ tons.

The exposed surface in one truss is 1,400 sq. ft. which should be increased 50% to cover the other truss. This gives a net pressure of 35 lb. per sq. ft. which is equivalent to a fairly stiff gale. The lateral displacement of the centre of buoyancy is $1{,}940 \div 386 = 5$ ft. The metacentre is 123 ft. above this point. No chances were taken, however, and on each occasion when a span was floated out there was practically neither wind nor current.

The span was built on the grillage at practically the level it would occupy on the piers.

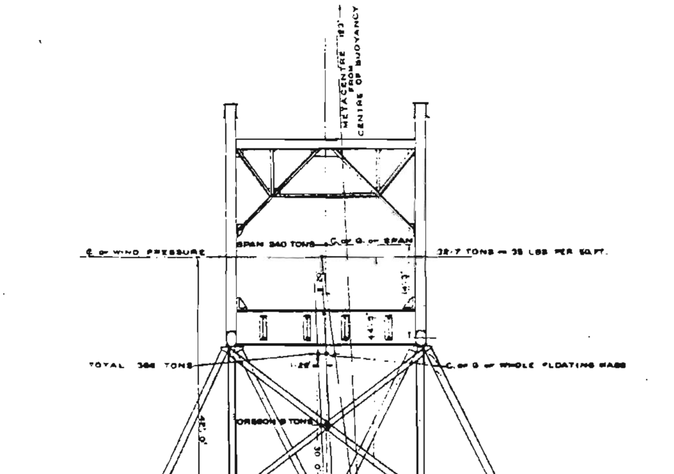



*Fig.* 13.—*Diagram showing Stability of Flotation Punt.*

Tidal rise and fall at Grafton are generally small and somewhat irregular. Readings with an automatic tide gauge were taken over a fairly long period but the data obtained were of a variable character, the limits ranging from 0 ft. to 3 ft. 6 in. and a low value of 12 in. was adopted as a reasonable expectation for an average spring tide. The flotation punts were in regular service for the transport of gravel and it was necessary to prepare them for their special duty by constructing on their decks a pair of five-legged pyramid-shaped trestles of 14 in. x 14 in. Oregon, with steel tops, supported on hardwood sills which distributed the load fairly uniformly over the punt framing (Fig. 13). Extra struts, 12 in. x 12 in., were provided, 14 ft. each side of the centre, which when wedged against the bottom chord took no load but helped to stabilize the punt. The most suitable place to lift the span was at the four points beneath the hip verticals which had sufficient section for their height to take the load safely. This gave ample room for the punts to lie alongside the piers when transferring the span to its bearings. Dredging was required in the vicinity of pier No. 1 and in the two bays in the grillage into which the punts entered. These, unloaded, had a draft of about 20 in. at the centre, equivalent to a displacement of 96 tons. The practice was to submerge each punt at low spring tide by opening the six sea-cocks until a freeboard at centre of about 1 ft. 6 in. had been obtained which gave, with a 26 ft. trestle, a clearance of 4 in. to the bottom faces of the lateral gusset plate at hip vertical or $2\frac{1}{2}$ in. to the bearing plate itself at end of span. Pieces of Oregon, 2 in. thick, were inserted between the pairs of approaching plates, as each punt rose under combined action of tide and pumping out, to equalize the pressure and, as these pieces were found to be practically uninjured, the object sought was, apparently, attained.

After making contact, each punt was unable to rise any higher until the total weight of water discharged by the pump was greater than that added by the span. A few inches of freeboard were gained when the span was afloat and this, combined with the tidal rise, gave the necessary clearance for quitting the grillage. Cables had already been attached to the steam winches on the punts carrying the shear legs which lay out in mid-stream and warped the floating structure outwards while cables to shore controlled by hand winches on the transport punts kept a check on the movement. As soon as the span cleared the grillage, cables with adjusting screws were carried from the four corners of each punt to the steelwork above and the tightening of these ensured that span and punts would act in any emergency as a single unit. Cable belts round the receiving piers enabled these to act as anchorages and the necessary turnings to be executed while the span was slowly warped into its final position, the necessary longitudinal adjustment being made by hand winches on the span itself. When the falling tide had left the span on its bearings, the sea-cocks were opened and the punts sufficiently submerged to get free of the span and take up their transport duties again after dismantling. The actual travelling time generally took an hour. Had any emergency arisen requiring more expeditious landing of the span, earlier and deeper submergence of the punts would have met the case.

Span *A* was floated out on 25/5/1930, *B* on 27/7/1930, *D* on 7/11/1930 and *C* on 3/4/1932, all Sundays, except in the case of *D* which was moved on a Friday. The delay in the flotation of *C* span arose from the necessity of keeping an opening in deep water for vessels until the bascule span which was erected on falsework was not only completed but in good working order, and some trouble was experienced before this was finally accomplished. The packing of the cast-iron blocks in the counterweight box and grouting up the clearances to form a solid mass proved a particularly irksome and tedious job. At the time the design was prepared, cast-iron was much cheaper than lead and the box was designed of a capacity to utilize this material in making up the necessary balance. Recently, the price of lead has fallen to a point which puts it on an economical par with cast-iron but too late to take advantage of except in a limited way. Some cast-iron has been discarded from the top of the box and replaced by lead to raise the centre of gravity of this portion of the mass and on the span itself, on the side where no track is required, the transoms have been also replaced by lead at a higher level for the same purpose. Some structural modifications were also found desirable in certain members of the counterweight framing to improve the running. Span *E*, next to the northern bank, was also erected on falsework, and, both in this case and that of the

bascule span, all steelwork was handled by the two punt-mounted shear legs which were 80 ft. high and operated by a steam winch of 10 tons capacity. These proved to be very efficient machines for this purpose. To float this span into position would have necessitated extensive dredging and the method adopted made it possible to carry on assembly and riveting work on two spans simultaneously, *C* being at the time on the grillage.

To reduce the travelling weight of the floating span all steelwork was omitted which added load without contributing to the strength or rigidity of the structure as, for instance, the road stringers and fences, the footway brackets and stringers and brackets for telephone lines. The assembly of the balance, about 470 tons, in the case of *A* span, took 252 man-days and the riveting 164 squad-days.

As span *A* at its fixed end carries the bascule span during its movement, a large amount of extra steelwork had to be erected after flotation, in addition to what has been enumerated above, bringing the finished weight to about 609 tons, including bearings. Span *B* had also some special steelwork and its finished weight was about 563 tons.

*Fig.* 14.—*Bascule in Open Position.*

CONCRETE.

The mix for caisson filling and piers (6 : 1) and for chamber sealing (4 : 1) has been already referred to, gravel and sand being used as it came from the river deposit with a sprinkling of "plums" in the former case. The water used was a minimum consistent with thorough packing. Concrete was not allowed to fall any height but was lowered in special buckets with hinged bottoms released by trigger when close to place of deposit. By careful attention to the timber forms which were of ample rigidity, well seasoned, tongued and grooved and planed on the contact side and by thorough spading between concrete and forms, it was possible, after stripping, to obtain a true and even face on the exposed surfaces without recourse to cement rendering. Six-inch concrete packing was provided under span bearings standing 2 in. proud of the general pier level and consisted of crushed gravel, $\frac{1}{4}$ in. to $1\frac{1}{4}$ in., and screened sand in the proportions of 4 : 2 : 1. In certain cases, a rapid setting cement was used. For the reinforced concrete road paving, kerbing and refuge floors, above materials were used but in proportions $3\frac{1}{2}$ : $2\frac{1}{2}$ : 1.1, as a result of tests made in the Testing Branch of the Public Works Department of New South Wales. The screened sand was found, on sieve analysis, to be on the coarse side, 12 per cent. retained on 0.1 in. mesh, producing a harsh mix, and, after experimenting with several proportions, the above was adopted as it gave excellent results, and on test showed a strength of 2,820 lb. after seven and 4,822 lb. after twenty-eight days. As the cement used in these cases was of unusual quality, the above values, when making comparisons, were reduced to 2,370 lb. and 4,050 lb., respectively, to accord with the cement used in previous tests. The 10 per cent. additional cement increased the strength nearly 11 per cent. This concrete weighed, on an average, 148 lb. per c. ft. and a c. ft. of stone yielded 1.38 c. ft. of concrete. A 4 : 2 : 1 mix, with stone up to 2 in. gauge, on test gave 4,816 lb. after twenty-eight days, a weight per c. ft. of 152 lb. and a yield of 1-18 cubic ft.

For the wearing and waterproofing strip, $1\frac{1}{2}$ in. thick, which was laid on the lower concrete within two hours of placing the latter, a mix of 3 : $1\frac{1}{2}$ : 1 was adopted, in accordance with the Main Roads Board practice, the crushed gravel ranging from $\frac{1}{4}$ in. to $\frac{3}{4}$ in. gauge. Concrete was conveyed from the mixer to the points where used by means of wagons running on a light gauge track in the middle of the road superstructure. In the construction of the road approaches, a flying fox was used to convey the concrete in the hinged buckets previously referred to.

ROAD APPROACHES.

On the northern side of the bridge the approach from the centre of Clarence Street to the end of the level skew span is 15 chains long and of this length $6\frac{1}{4}$ chains are on an embankment graded 1 in 22 and the balance on a concrete and steel viaduct, crossing Kent Street, graded 1 in 25, the upper portion being on a curve of about 4 chains radius. The viaduct is carried on double shaft tapered piers, 42 ft., centre to centre, and rising to a maximum height of 36 ft. The deck, 22 ft. 6 in. between kerbs, consists of seven rolled steel girders, 24 in. x $7\frac{1}{2}$ in. x 100 lb., with brick arches turned between them carrying a four-to-one concrete floor protected by bituminous waterproofing, $\frac{3}{4}$ in. thick. A concrete paving strip is provided, $2\frac{1}{2}$ in. thick, of similar composition to that on the main bridge. Concrete panelled parapet walls, $3\frac{1}{2}$ : $2\frac{1}{2}$ : 1.1 mix, reinforced over Kent Street and at all pilasters, give the necessary protection and a decorative touch. The road has a 9 in. superelevation on the curve and at the junction of the two skew spans with the main span.

On the embankment which extends into Clarence Street, a concrete road paving is provided, 20 ft. wide, $6\frac{1}{2}$ in. thick at centre and 9 in. at edges with central longitudinal joint and transverse joints at 45 ft. intervals. The concrete mix is $3\frac{1}{2}$ : 2 : 1, reinforced, and the paving, generally, conforms to Main Roads Board practice.

On the southern side of the bridge there are two viaduct spans and a short paved embankment, all on 1 in 25 grade, and constructed on similar lines to the northern approach.

The footway approach on each side is concrete paved, with steps and grades to suit the ground, handrailing and,

to give connection between the two bridge footways, a subway 8 ft. wide under the railway.

PAINTING.

Metalwork received a priming coat of red lead in the shop, members in contact being coated before fixing. In the field a further coat was applied either of red lead, red lead and ferrodor or red lead and red oxide of iron, two to one. Two finishing coats of ferrodor were then laid on. Part of the structure was spray painted but for the major portion brushes were used. Gates and handrailing of road fence were painted white and fences and operating cabin light stone.

WARNING DEVICES.

The general arrangement of warning devices is shown on Fig. 2 of Part I. On the roadway, the standard red triangle, studded with "cats-eyes," with legend above, *Lift Bridge*, is displayed at about 100 yards from the barrier

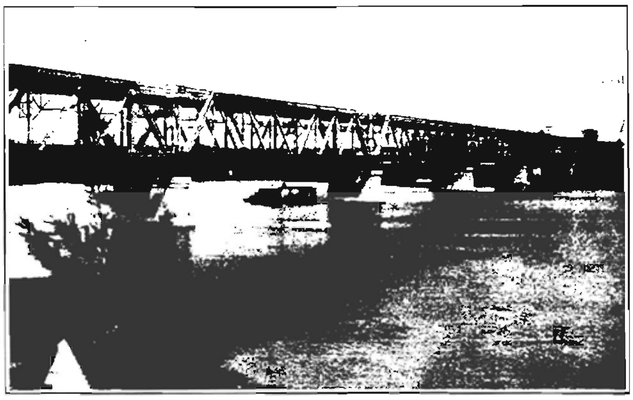


*Fig. 15.—General View of Completed Bridge.*

gates on the northern and 70 yards on the southern side. White letters are used on a black background. Midway between these and the gates, in each case, gongs and lights are provided and a warning to road-users to stop when the gong sounds. A large circular enamelled disc is fixed to the double gates, half on each, with words *Stop. Bridge Closed. Span Open* in black letters on a yellow background. The word *Stop* is studded with cats-eyes. On the footways gongs and lights are also provided and warnings to keep outside the gates when the gong sounds.

LIGHTING.

The general lighting of the bridge has been carried out by the Clarence County Council for the Grafton and South Grafton Muncipal Councils. The Transport Department provided the red and green navigation lights on piers Nos. 2 and 3, on the dolphins and, including yellow acknowledgment light, on the mast over the operating cabin, also lighting of cabin and gear platforms.

DOLPHINS.

The general arrangement of the dolphins is shown on Fig. 2 of Part I. The principal structure surrounds pier No. 2 which is vital to the support and operation of the bascule span and is on the side of the channel to which wind and current and the conformation of the southern bank will tend to force vessels. This structure is 263 ft. long, centre to centre of end piles, and 20 ft. wide with tapered ends. The portion fronting the pier is a box truss 63 ft. long, 4 ft. horizontal and 5 ft. vertical depth. Four stages are provided, 40 ft. back from front row of piles, to carry the ends of heavy stud link chains, 60 ton proof load, 90 ft. long attached to 2½-ton anchors buried below the river bed. Rigging screws are provided at the upper ends which are used to tighten the chains to a definite sag and pull. They then act as powerful springs to absorb impact from a colliding vessel. Mooring hooks and fair-leads are provided at intervals to enable vessels to warp themselves through the channel when the conditions so demand. On this side, beyond the ends of the main dolphin, are four five-pile groups which extend the channel giving mooring length for vessels on each side of the bridge. On the northern side there are four four-pile groups forming an alignment 185 ft. long. The clear width between fenders of the two systems is 66 ft., and the maximum beam of any vessel so far using the channel is 34 ft. Piles are mostly ironbark, stripped of bark and sheathed with soft rolled copper, 22 gauge, for 53 ft. of their length, of which 6 ft. are below river bed, and 3 ft. above mean high water. Timber superstructure is ironbark and decking brush-box, all coated with wood preserving oil.

SIGNALLING.

The signalling equipment consists of an intermediate staff instrument on a platform at about rail level below the operating cabin, controlling a lever operating a plunger which locks the rail lift. A telephone provides communication with both South Grafton and Grafton. For pilot-working, a pilotman's duplex lock is provided at South Grafton. The withdrawal of the plunger, unlocking the rail lift, closes a circuit to the magnetic switch in the cabin which makes current available for all operations when the oil circuit breaker is closed. A stairway gives access from this platform to the cabin where all subsequent actions take place. The operator is a traffic employee, otherwise on duty at South Grafton, conversant with safe working principles and trained, with others, in the proper method of operating the various switches. The complete sequence of operations is given in detail in Appendix C of Part I. of the paper.

CONCLUSION.

The total amount of metal work in the bridge and approaches, including caissons, machinery and reinforcing bars, is, in round figures, 4,900 tons and of this about 42 per cent. was rolled or cast in New South Wales, but the whole of it, with the exception of the rack-teeth and driving pinions, was fabricated into bridge material by local firms. Some of the gear cutting was done in Melbourne. The total amount of concrete placed of all kinds is 16,500 c. yd. and of piles driven, in permanent work only, is 16,000 linear feet.

The total cost of the work to date is £408,723 and the only work now proceeding is the painting of the steelwork, which is well forward, and provision of four extra dolphin groups. The original cost of plant was £42,598 and of this £17,852 have been written off and charged to the work, being included in above total. The balance, not included,

will also remain as a charge until such time as the plant is transferred or sold, in whole or in part, when it will be reduced to the extent of the credit obtained. Part of the total cost is debited to the railway and part to the roadway capital account, but the final allocation has not yet been made.

During the five years of construction in the field, the river rose on several occasions to a height of 8 ft. above normal and, though much delay was caused, there was no great amount of damage or loss. A number of minor accidents also occurred but only one fatality, which arose from an unfortunate error of judgment on the part of the victim.

The bridge was opened, for railway traffic only, on 8th May, 1932, and for vehicular and pedestrian traffic on 19th July, 1932.

### Administration and Acknowledgments.

The design and construction of the Clarence River bridge, since its first inception in 1910, have been in the hands of the staff of the Railway and Tramway Construction Branch which, until 1st January, 1917, was an integral unit of the Public Works Department. On and from that date it was transferred by Act of Parliament to the Railway and Tramway Department, preserving its integrity. From early in 1904 until 1st January, 1925, Mr. Wm. Hutchinson, M.I.E.Aust., directed the activities of the Branch and he was succeeded on the latter date by Mr. F. E. Wickham, M.I.E.Aust., who occupied the position until 3rd March, 1930, with Mr. W. R. Beaver, A.M.I.E.Aust., Assistant Chief Engineer. On this date the branch was affiliated with the Existing Lines Branch under the Engineer-in-Chief for the latter, Mr. R. L. Ranken, M.I.E.Aust., who took the title Chief Civil Engineer. The construction work of the branch, however, still remained under the immediate direction of Mr. Beaver until the recent passing of the Transport Act under which Mr. A. C. Fewtrell, A.M.I.E. Aust., was appointed Transport Commissioner for Ways and Works. Mr. Beaver, subsequently, took up duties as Civil Engineer at Bathurst and Mr. V. W. Mahoney, A.M.I.E.Aust., formerly Inspecting Engineer to the Branch, was given control of construction work, including the Clarence River bridge. Mr. J. D. Simpson, A.M.I.E.Aust., occupied the position of Inspecting Engineer prior to Mr. Mahoney and supervised the early work on the bridge. Mr. S. D. Webb, A.M.I.E.Aust., has been in charge of the field work since August, 1927, and has had associated with him, as works manager, Mr. W. Rees, doyen of practical bridge builders in the Commonwealth.

Mr. C. A. Edwards was responsible for the location of the bridge and for the original route of the extension and Mr. F. E. Wilson for the base lines and triangulation work to establish the pier centres and for the final route as constructed. The inspection and testing of the electrical machinery required to operate the moving span and in the construction plant were carried out by Mr. G. A. Twigg, A.M.I.E.Aust., of the Electrical Branch of the Transport Department.

The author was in charge of the design staff of the branch from January, 1911, until October, 1930, when he became associated with Mr. R. J. Boyd, M.I.E.Aust., of the Metropolitan Railway Construction Branch, in the supervision of the combined design and drawing staffs of the two construction branches and of the Existing Lines Branch but retaining control of work connected with the bridge. The officers most deeply concerned in the design work of the bridge were Mr. E. P. Boaden, A.M.I.E.Aust., (bascule span, machinery and electrical equipment), Mr. J. England, A.M.I.E.Aust., (fixed spans and reinforced concrete work), Mr. A. Greig (co-ordination, checking, plant and caisson design) and Mr. L. T. Swift (mechanical and electrical details).

Acknowledgment is due, and is tendered, with thanks, to Messrs. England and Greig for design notes and to the latter also for supervision of drawings for the paper and to Mr. Boaden for a substantial contribution to the letterpress and illustrations.

For the field notes, the author is largely indebted to Messrs. Mahoney and Webb for information kindly supplied.

# Engineering Conference Brisbane—1933

The Preliminary Notice of the 1933 Engineering Conference was distributed as a supplement to the November issue of The Journal.

Only those completing the " notification of desire to attend," included therein, will receive further detailed particulars of the Conference.

Please assist the Organising Committee by communicating with the Secretary of the Brisbane Division of The Institution at the earliest possible date.

## APPENDIX C

### Heritage listings for elements of the railway

(There are also a number of station buildings and precincts along the route with heritage listings which are not included)

# Grafton Rail and Road Bridge

## Item

**Name of Item:** Grafton Rail and Road Bridge

**Other Name/s:** Clarence River Bridge

**Type of Item:** Built

**Group/Collection:** Transport - Rail

**Category:** Railway Bridge/ Viaduct

**Primary Address:** North Coast Railway, Grafton, NSW 2460

**Local Govt. Area:** Clarence Valley

**Property Description:**

| Lot/Volume Code | Lot/Volume Number | Section Number | Plan/Folio Code | Plan/Folio Number |
|---|---|---|---|---|

**Boundary:** The listing boundary for each structure includes the structure, the piers, abutments, embankments and track formation for a distance of 10 metres in all directions from those elements.

**All Addresses**

| Street Address | Suburb/Town | LGA | Parish | County | Type |
|---|---|---|---|---|---|
| North Coast Railway | Grafton | Clarence Valley | | | Primary |
| Pacific Highway | Grafton | Clarence Valley | | | Alternate |

## Statement of Significance

This bridge is a double-deck road/rail structure, the only one of its type in NSW and is acknowledged as significant to the State. It has a lift span to allow passing of river traffic but this is no longer used. It presents a commanding visual reminder of rail and road to residents of Grafton and is historically signficant and its opening in 1932 completed the North coast standard gauge line between Sydney and Brisbane, avoiding the winding road route via Tenterfield.

The viaduct along with the wharf remains are important relics of the development of the north coast railway. The viaduct is representative of similar structures constructed at a range of locations, many of which have been replaced.

This bridge is a double-deck road/rail structure, the only one of its type in NSW. There is a lift span to allow passing of river traffic (no longer used). It presents a commanding visual reminder of rail and road to residents of Grafton. Opening of the bridge in 1932 completed the North coast standard gauge line between Sydney and Brisbane, avoiding the winding route via Tenterfield.
The viaduct along with the wharf remains are important relics of the development of the north coast railway. The viaduct is representative of similar structures constructed at a range of locations, many of which have been replaced.
**Date Significance Updated:** 04 Jun 08

Note: There are incomplete details for a number of items listed in NSW. The Heritage Branch intends to develop or upgrade statements of significance and other information for these items as resources become available.

## Description

**Designer/Maker:** J W Roberts.

**Builder/Maker:** Railway and Tramway Authority

**Physical Description:** STRUCTURES
bridge across Clarence River - double deck road/rail bridge with Bascule span, 1932, RNE
timber viaduct south of station, 1915

As early as 1910 the Chief Commissioner of the New South Wales Railways wrote to the Public Works Department pointing out the necessity of a bridge over the Clarence River at Grafton and, although plans were prepared for a tentative six-span design by the Public Works Department, they were shelved with the outbreak of the First World War, so train ferries and vehicular punts continued to be used. Various sites had been looked at for the bridge, including Susan Island, Mountain View, and the present location, known as Wilsons Hill. Before actual working drawings were commenced a complete reinvestigation was made of the most efficient form of pier and method of sinking, etc. A solid pier in one unit was finally decided on for piers Nos 2,3 & 4 to be sunk to rock by means of rectangular steel caissons, and for the pier in the southern bank of clay an open excavation was chosen. Five spans were decided on and the bascule span was the Scherzer rolling type, a swing span and vertical lift span having been earlier ruled out. The amended design of the railway bridge was approved & working drawings were begun by the Railway & Tramway Department early in 1921. However, when the drawings were well advanced in December, 1922, the Minister for Works asked the Railways Commissioners to prepare new designs and estimates for a bridge to carry vehicular traffic as well. Alternative schemes were considered but putting a roadway above the railway was found to be not only the cheapest arrangement but also allowed all the previous calculations to be used. The original departmental estimate for the bridge was 400,000 pounds and when tenders were called in June, 1927, with a stipulation that only Australian steel be used throughout, only two were received, one for 488,000 pounds and the other for 497,000 pounds, so the department decided to do the work itself and in the event did it for less than its own estimate -- a far cry from modern construction estimates. Preliminary work was started in August and in the same year tenders were accepted from the Clyde Engineering Company Ltd for the manufacture and supply of steelwork for the caissons (22,000 pounds) and for the superstructure (144,500 pounds). In June, 1928, the first big pontoon for use in the work was launched at Grafton and in July the first rivet was driven by Minister for Works and Railways. In October the excavations for the first pier on the southern bank of the river were completed and filling with concrete began. Building the remaining piers proved to be the most arduous and difficult part of the undertaking but in May, 1930, the first span was floated into position and the last span early in 1932. All the bridge members were built at Granville, sent up by train, then assembled on site. The most fascinating feature of the bridge is the bascule, which was electrically operated by two 35 horsepower (26kW) motors powered by the Nymboida hydro-electric scheme. The span is of the Rall (combined rotating and travelling) type, weighs 800 tons and is carried on two large steel rollers each about 5 ft (1.5m) in diameter and 2 ft (0.6m) in width, which rolled on a steel track. The rollers moved away from the opening simultaneously with the upward rotation of the span, so that with the maximum angular movement of 80 degrees the rollers had moved back 12 ft 6 ins (3.8m) from their original position. This left an opening of 70 ft (21.3m) and with 40 ft (12.2m) of water in the channel vessels of up to 2,500 tons could pass through. The whole lifting operation took 2 minutes and occurred 4-5 times a week. As finally built the bridge consists of five steel truss spans of from 212 ft 6 ins (74m) to 245 ft (75m) in length, with the bascule span of 76 ft (23.2m) and two approach spans, being 66 ft (20m) long for the railway and 100 ft (30.5m) long for the

roadway. The total length of the bridge is 1,500 ft (457m) and it spans 1,300 (396m) of water. CONSTRUCTION OF THE DAM (continued) During construction of the dam extensive use was made of electricity on site, and production line techniques for the quarrying of stone blocks were used for the first time. SUMMARY OF THE SPECIFICATIONS OF THE DAM Date of construction: 1902 - 1907 Masonry in wall and spillway: 148,000 cu. yds (113,220 cu. m) Length of dam: 811 ft (247.2m) Length of bywash: 684.5 ft (208.6m) Width at base: 156 ft (47.6m) Width at crest: 16.5 ft (5m) Greatest depth of water: 150 ft (45.7m) Full supply level: 950 ft above sea level (289.5m) Area of lake: 2,104 acres (851.5 ha) Capacity: 20,743 million gallons (94,298 million litres) The water from Cataract Dam is discharged as required into the Cataract River downstream to Broughton's Pass. There it is diverted by another weir into Cataract Tunnel, 2 miles 93.2 km) long, the first structure of the Upper Canal by which it is conveyed to Prospect Reservoir. Also to be included in this classification is the CATARACT DAM OFFICIAL QUARTERS, situated close to the dam wall at the northern end. This single storey Federation house was built in 1910 for the use of Water Board staff during construction of the dam. It is built of ashlar masonry quarried on the site and features a verandah at the front with white painted timber posts with curved brackets and gabled entrance way. When built the house contained a board room, offices, four bedrooms and a kitchen. Over the years it provided accommodation for inspecting officers and important visitors. Today it is still used by the Water Board and can now provide sleeping accommodation for 12 people. The gardens around the house are landscaped and the garden beds edged with sandstone. Also made of sandstone is a detached garage and two amenity blocks. Surrounding the garden is a castellated sandstone fence with decorative entrance posts. A further three sandstone cottages are located nearly as well as a brick cottage. The Cataract Dam site is a very popular tourist attraction. The public area surrounding the dam is beautifully maintained by the Water Board and a large picnic area, shelter sheds, fireplaces and playground area are provided. There are also attractive gardens and bushwalks. BOUNDARY AND CURTILAGE Classification to include Dam Wall, Official Quarters and grounds defined by line from dam wall trig (9029-II-N GR 975060) to road junction at entrance to picnic area (GR 981066) around vehicle track to landing area (GR983060) and line projected back to dam wall trig. Architectural Style: Scherzer rolling type bascule span bridge. Building Material: Steel

A 6-truss steel bridge linking South Grafton to Grafton. It has the distinction of being a double-deck bridge, the road being on top of the trusses, and having a double-deck bascule span for ships to pass through.

Its design was the crowning achievement of the distinguished bridge engineer J W Roberts.

Drawings in PH 1711 (3 rolls).

| | |
|---|---|
| **Physical Condition and/or Archaeological Potential:** | Well maintained **Date Condition Updated:** 21 Mar 07 |
| **Current Use:** | Rail /Road Bridge |
| **Former Use:** | Rail/Road Bridge |

## History

**Historical Notes:** The Clarence River bridge, spanning the largest of the northern rivers, is a unique structure. It is the only one of its kind in Australia, and therefore its completion may be regarded as an important epoch in the history of bridge construction. For many years the Clarence was the main obstacle in completing the rail link between Sydney and Grafton and as far back as 1905 Grafton was connected by rail with Casino in the north and in 1915 South Grafton was joined with Glenreagh in the south. When the Clarence River Bridge was built it closed the last gap in the interstate unified-gauge railway line linking not only Sydney

and Brisbane & taking over an hour off the journey but also completing the rail link from Cairns to Perth. The first train ran over the new bridge on the 7th May, 1932, and was the largest ever run in the State (weighing over 500 tons, consisting of 15 carriages carrying 1,700 passengers

Between the first and second Hawkesbury bridges, this bridge was the next largest steel railway bridge project in NSW.

It has the unique features, in the NSW railway system, of double deck trusses with the road on top, and an American patented double deck bascule span to allow ships to pass through. Currently, the bascule span is not operative.

The North Coast railway from Maitland to south Brisbane was built in stages starting at Maitland in 1910. By the late 1920's only the crossing of the Clarence River remained with the Ferry, "Swallow" trans-shipping rolling stock and passengers.

The original bridge design did not include the road but a 1922 government decision changed that.

## Historic Themes

| Australian Theme (abbrev) | New South Wales Theme | Local Theme |
|---|---|---|
| 3. Economy - Developing local, regional and national economies | Transport - Activities associated with the moving of people and goods from one place to another, and systems for the provision of such movements | (none) - |

## Assessment of Significance

**SHR Criteria f)** [Rarity]

This item is assessed as historically rare. This item is assessed as scientifically rare. This item is assessed as arch. rare. This item is assessed as socially rare.

**Assessment Criteria**

Items are assessed against the **State Heritage Register (SHR) Criteria** to determine the level of significance. Refer to the Listings below for the level of statutory protection.

## Listings

| Heritage Listing | Listing Title | Listing Number | Gazette Date | Gazette Number | Gazette Page |
|---|---|---|---|---|---|
| *Regional Environmental Plan* | | | 23 Dec 94 | | |
| *Local Environmental Plan* | Schedule 1 | | 23 Sep 88 | 147 | 5033 |
| *Heritage study* | | | | | |

## Study Details

| Title | Year | Number | Author | Inspected by | Guidelines Used |
|---|---|---|---|---|---|
| State Rail Authority Section 170 Register | 1997 | SRA237 | State Rail Authority | | No |
| Grafton Community Heritage Study | 2004 | | J. Gardiner | | Yes |

## References, Internet links & Images

| Type | Author | Year | Title | Internet Links |
|---|---|---|---|---|
| Written | Donald Ellsmore | 2004 | Surplus Railway Lands in the City of Grafton, NSW Conservation Management Plan | |
| Written | R. Bremmer | 1982 | Crossing the Clarence. ROUNDHOUSE July, 1982. MAIN ROADS Vol 47, Nos 3 & 4, 1982. | |
| Written | Simpson, P J | 0 | National Trust of Australia (NSW) | |

Note: Internet links may be to web pages, documents or images.



**(Click on Thumbnail for Full Size Image and Image Details)**

## Data Source

The information for this entry comes from the following source:

**Name:** Local Government

**Database Number:** 1640224

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# Clarence River Bridge, Grafton

## Item

**Name of Item:** Clarence River Bridge, Grafton

**Type of Item:** Built

**Group/Collection:** Transport - Rail

**Category:** Railway Bridge/ Viaduct

**Primary Address:** Steel Trusses 0.5 Km Past South Grafton, Grafton, NSW 2460

**Local Govt. Area:** Clarence Valley

**Property Description:**

| Lot/Volume Code | Lot/Volume Number | Section Number | Plan/Folio Code | Plan/Folio Number |
|---|---|---|---|---|

**All Addresses**

| Street Address | Suburb/Town | LGA | Parish | County | Type |
|---|---|---|---|---|---|
| Steel Trusses 0.5 Km Past South Grafton | Grafton | Clarence Valley | | | Primary |

## Owner/s

| Organisation Name | Owner Category | Date Ownership Updated |
|---|---|---|
| RailCorp | State Government | |

## Statement of Significance

Between the first and second Hawkesbury bridges, this bridge was the next largest steel railway bridge project.

It has the unique features, in the NSW railway system, of double deck trusses with the road on top, and an American patented double deck bascule span to allow ships to pass through. Currently, the bascule span is not operative.

Note: There are incomplete details for a number of items listed in NSW. The Heritage Branch intends to develop or upgrade statements of significance and other information for these items as resources become available.

## Description

**Construction Years:** 1932 -

**Physical Description:** A 6-truss steel bridge linking South Grafton to Grafton. It has the distinction of being a double-deck bridge, the road being on top of the trusses, and having a double-deck bascule span for ships to pass through.

Its design was the crowning achievement of the distinguished bridge engineer J W Roberts.

Drawings in PH 1711 (3 rolls).

**Physical Condition and/or Archaeological Potential:** Good

## History

**Historical Notes:**

The North Coast railway from Maitland to south Brisbane was built in stages starting at Maitland in 1910. By the late 1920's only the crossing of the Clarence River remained with the Ferry, "Swallow" trans-shipping rolling stock and passengers.

The original bridge design did not include the road but a 1922 government decision changed that.

## Historic Themes

| Australian Theme (abbrev) | New South Wales Theme | Local Theme |
|---|---|---|
| 3. Economy - Developing local, regional and national economies | Transport - Activities associated with the moving of people and goods from one place to another, and systems for the provision of such movements | (none) - |

**Assessment Criteria**

Items are assessed against the **State Heritage Register (SHR) Criteria** to determine the level of significance. Refer to the Listings below for the level of statutory protection.

## Listings

| Heritage Listing | Listing Title | Listing Number | Gazette Date | Gazette Number | Gazette Page |
|---|---|---|---|---|---|
| *Heritage Act - s.170 NSW State agency heritage register* | SRA s.170 Register | | | | |

## Study Details

| Title | Year | Number | Author | Inspected by | Guidelines Used |
|---|---|---|---|---|---|
| State Rail Authority Heritage Register Study | 1999 | SRA851 | State Rail Authority | | No |

## References, Internet links & Images

| Type | Author | Year | Title | Internet Links |
|---|---|---|---|---|
| Written | | | Check SRA archive's historical notes for the North Coast railway. See "Bridges Down Under" Pages 115 - 118. See also the two 1932, I E Australia papers by | |

Note: Internet links may be to web pages, documents or images.

## Data Source

The information for this entry comes from the following source:

| | |
|---|---|
| **Name:** | State Government Agency |
| **Database Number:** | 4440851 |

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# Grafton rail and road bridge over Clarence River

## Item

| | |
|---|---|
| **Name of Item:** | Grafton rail and road bridge over Clarence River |
| **Other Name/s:** | Clarence River Bridge |
| **Type of Item:** | Built |
| **Group/Collection:** | Transport - Rail |
| **Category:** | Railway Bridge/ Viaduct |
| **Location:** | Lat:152.9420951 Long:-29.69779765 |
| **Primary Address:** | North Coast railway, Grafton, NSW 2460 |
| **Local Govt. Area:** | Clarence Valley |

**Property Description:**

| Lot/Volume Code | Lot/Volume Number | Section Number | Plan/Folio Code | Plan/Folio Number |
|---|---|---|---|---|

**Boundary:** The listing boundary for each structure includes the structure, the piers, abutments, embankments and track formation for a distance of 10 metres in all directions from those elements.

**All Addresses**

| Street Address | Suburb/Town | LGA | Parish | County | Type |
|---|---|---|---|---|---|
| North Coast railway | Grafton | Clarence Valley | | | Primary |
| Pacific Highway | Grafton | Clarence Valley | | | Alternate |

## Owner/s

| Organisation Name | Owner Category | Date Ownership Updated |
|---|---|---|
| Rail Infrastructure Corporation | State Government | |

## Statement of Significance

This bridge is a double-deck road/rail structure, the only one of its type in NSW. There is a lift span to allow passing of river traffic (no longer used). It presents a commanding visual reminder of rail and road to residents of Grafton. Opening of the bridge in 1932 completed the North coast standard guage line between Sydney and Brisbane, avoiding the winding route via Tenterfield.
The viaduct along with the wharf remains are important relics of the development of the north coast railway. The viaduct is representative of similar structures constructed at a range of locations, many of which have been replaced.

Note: There are incomplete details for a number of items listed in NSW. The Heritage Branch intends to develop or upgrade statements of significance and other information for these items as resources become available.

## Description

**Physical Description:** STRUCTURES
bridge across Clarence River - double deck road/rail bridge with Bascule span, 1932, RNE
timber viaduct south of station, 1915

## Historic Themes

| Australian Theme (abbrev) | New South Wales Theme | Local Theme |
|---|---|---|
| 3. Economy - Developing local, regional and national economies | Transport - Activities associated with the moving of people and goods from one place to another, and systems for the provision of such movements | (none) - |

## Assessment of Significance

**SHR Criteria f)** [Rarity]
This item is assessed as historically rare. This item is assessed as scientifically rare. This item is assessed as arch. rare. This item is assessed as socially rare.

**Assessment Criteria**
Items are assessed against the **State Heritage Register (SHR) Criteria** to determine the level of significance. Refer to the Listings below for the level of statutory protection.

## Procedures / Exemptions

| Section of Act | Description | Title | Comments | Action Date |
|---|---|---|---|---|
| 57(2) | Exemption to allow work | Standard Exemptions | SCHEDULE OF STANDARD EXEMPTIONS<br>HERITAGE ACT 1977<br>Notice of Order Under Section 57 (2) of the Heritage Act 1977<br><br>I, the Minister for Planning, pursuant to subsection 57 (2) of the Heritage Act 1977, on the recommendation of the Heritage Council of New South Wales, do by this Order:<br><br>1. revoke the Schedule of Exemptions to subsection 57(1) of the Heritage Act made under subsection 57 (2) and published in the Government Gazette on 22 February 2008; and<br><br>2. grant standard exemptions from subsection 57(1) of the Heritage Act 1977, described in the Schedule attached.<br><br>FRANK SARTOR<br>Minister for Planning<br>Sydney, 11 July 2008<br><br>To view the schedule click on the Standard Exemptions for Works Requiring Heritage Council Approval link below. | Sep 5 2008 |

**Standard Exemptions** for Works Requiring Heritage Council Approval

## Listings

| Heritage Listing | Listing Title | Listing Number | Gazette Date | Gazette Number | Gazette Page |
|---|---|---|---|---|---|
| *Heritage Act - State Heritage Register* | | 01036 | 02 Apr 99 | 27 | 1546 |
| *Heritage Act - Icons Project Nomination for SHR listing* | | | 20 Jul 04 | | |
| *Heritage Act - s.170 NSW State agency heritage register* | | | | | |
| *Regional Environmental Plan* | | | 23 Dec 94 | | |
| *Local Environmental Plan* | Schedule 1 | | 23 Sep 88 | 147 | 5033 |

## Study Details

| Title | Year | Number | Author | Inspected by | Guidelines Used |
|---|---|---|---|---|---|
| State Rail Authority Section 170 Register | 1997 | SRA237 | State Rail Authority | | No |

## References, Internet links & Images

None

Note: Internet links may be to web pages, documents or images.

## Data Source

The information for this entry comes from the following source:

**Name:** Heritage Branch

**Database Number:** 5045477

**File Number:** H03/00026; H04/00091/4 (ICONS)

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# Clarence River, Grafton Underbridge

## Item

**Name of Item:** Clarence River, Grafton Underbridge

**Type of Item:** Built

**Group/Collection:** Transport - Rail

**Category:** Railway Bridge/ Viaduct

**Primary Address:** Concrete Beams North End Of Bridge, Grafton, NSW 2460

**Local Govt. Area:** Clarence Valley

**Property Description:**

| Lot/Volume Code | Lot/Volume Number | Section Number | Plan/Folio Code | Plan/Folio Number |
|---|---|---|---|---|

**All Addresses**

| Street Address | Suburb/Town | LGA | Parish | County | Type |
|---|---|---|---|---|---|
| Concrete Beams North End Of Bridge | Grafton | Clarence Valley | | | Primary |

## Owner/s

| Organisation Name | Owner Category | Date Ownership Updated |
|---|---|---|
| RailCorp | State Government | |

## Statement of Significance

Possibly the first use of precast reinforced concrete beams, in keeping with the extensive use of concrete for the street crossings by the new railway through Grafton.

Note: There are incomplete details for a number of items listed in NSW. The Heritage Branch intends to develop or upgrade statements of significance and other information for these items as resources become available.

## Description

**Construction Years:** 1932 -

**Physical Description:** 13 X 20ft (6.1m) precast concrete beams linking North end of steel truss bridge to the Northern approach viaduct.

Drawings 553 - 5-K, check details.

**Physical Condition and/or Archaeological Potential:** Good

## History

**Historical Notes:**

Plain/Mass concrete has been extensively used for foundations and walls since the 1890's. by 1910 reinforced concrete was in use, but not for superstructures directly supporting the tracks. The Locksley "culvert" was an experiment to compare costs with brick construction. Brick arch construction prevailed until the 1920's.

Some reinforced concrete slab, and girder, underbridges were built between 1919 and 1933 but steel bridges prevailed for another 40 years until prestressed concrete became widely used.

## Historic Themes

| Australian Theme (abbrev) | New South Wales Theme | Local Theme |
|---|---|---|
| 3. Economy - Developing local, regional and national economies | Transport - Activities associated with the moving of people and goods from one place to another, and systems for the provision of such movements | (none) - |

**Assessment Criteria**

Items are assessed against the **State Heritage Register (SHR) Criteria** to determine the level of significance. Refer to the Listings below for the level of statutory protection.

## Listings

| Heritage Listing | Listing Title | Listing Number | Gazette Date | Gazette Number | Gazette Page |
|---|---|---|---|---|---|
| *Heritage Act - s.170 NSW State agency heritage register* | SRA s.170 Register | | | | |

## Study Details

| Title | Year | Number | Author | Inspected by | Guidelines Used |
|---|---|---|---|---|---|
| State Rail Authority Heritage Register Study | 1999 | SRA837 | State Rail Authority | | No |

## References, Internet links & Images

| Type | Author | Year | Title | Internet Links |
|---|---|---|---|---|
| Written | | | Check SRA archive's historical notes for the North Coast railway. | |

Note: Internet links may be to web pages, documents or images.

## Data Source

The information for this entry comes from the following source:

**Name:** State Government Agency

**Database Number:** 4440837

Every effort has been made to ensure that information contained in the State Heritage Inventory is correct. If you find any errors or omissions please send your comments to the **Database Manager**.

owners.

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# The Risk Water Facilities

## Item

**Name of Item:** The Risk Water Facilities

**Type of Item:** Built

**Group/Collection:** Transport - Rail

**Category:** Railway Water Tower/ Tank

**Primary Address:** The Risk, NSW 2474

**Local Govt. Area:** Kyogle

**Property Description:**

| Lot/Volume Code | Lot/Volume Number | Section Number | Plan/Folio Code | Plan/Folio Number |
|---|---|---|---|---|

**Boundary:** The listing boundary is the area around each item for a distance of 50 metres in all directions.

**All Addresses**

| Street Address | Suburb/Town | LGA | Parish | County | Type |
|---|---|---|---|---|---|
| | The Risk | Kyogle | | | Primary |

## Owner/s

| Organisation Name | Owner Category | Date Ownership Updated |
|---|---|---|
| RailCorp | State Government | |

## Statement of Significance

This is an excellent group of water facilities including reservoir, tanks and columns. It is a reminder of the infrastructure needed for the steam locomotive and the remote location of facilities due to the need to provide regular water supplies.

Note: There are incomplete details for a number of items listed in NSW. The Heritage Branch intends to develop or upgrade statements of significance and other information for these items as resources become available.

## Description

**Physical Description:**

STRUCTURES
water tank and stand - sheet metal, located away from yard
water column with jib and overhead tank - located between loop and main line
water resevoir - outside boundary of property
pump to water reservoir

## History

**Historical Notes:** X

## Historic Themes

| Australian Theme (abbrev) | New South Wales Theme | Local Theme |
|---|---|---|
| 3. Economy - Developing local, regional and national economies | Transport - Activities associated with the moving of people and goods from one place to another, and systems for the provision of such movements | (none) - |

## Assessment of Significance

**SHR Criteria f)** [Rarity] — This item is assessed as historically rare. This item is assessed as scientifically rare.

**Assessment Criteria** — Items are assessed against the **State Heritage Register (SHR) Criteria** to determine the level of significance. Refer to the Listings below for the level of statutory protection.

## Listings

| Heritage Listing | Listing Title | Listing Number | Gazette Date | Gazette Number | Gazette Page |
|---|---|---|---|---|---|
| *Heritage Act - s.170 NSW State agency heritage register* | SRA s.170 Register | | | | |

## Study Details

| Title | Year | Number | Author | Inspected by | Guidelines Used |
|---|---|---|---|---|---|
| State Rail Authority Heritage Register Study | 1999 | SRA233 | State Rail Authority | | No |

## References, Internet links & Images

None

Note: Internet links may be to web pages, documents or images.

## Data Source

The information for this entry comes from the following source:

**Name:** State Government Agency

**Database Number:** 4440233

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# Border Loop railway formation and landscape

## Item

**Name of Item:** Border Loop railway formation and landscape

**Type of Item:** Complex / Group

**Group/Collection:** Transport - Rail

**Category:** Railway

**Location:** Lat:152.96214665 Long:-28.35295588

**Primary Address:** North Coast Railway, Cougal, NSW

**Local Govt. Area:** Kyogle

**Property Description:**

| Lot/Volume Code | Lot/Volume Number | Section Number | Plan/Folio Code | Plan/Folio Number |
|---|---|---|---|---|

**Boundary:** The listing boundary is the whole section of line withinthe SRA property boundaries along the tracks including structures, foundations, formation, etc from Congal to the north end ofthe border tunnel.

**All Addresses**

| Street Address | Suburb/Town | LGA | Parish | County | Type |
|---|---|---|---|---|---|
| North Coast Railway | Cougal | Kyogle | | | Primary |

## Owner/s

| Organisation Name | Owner Category | Date Ownership Updated |
|---|---|---|
| RailCorp | State Government | 21 Oct 98 |

## Statement of Significance

This section of line contains a unique set of later structures vividly showing how the railway line was built to surmount the summit of Richmond Gap on the NSW/Qld border. The spiral is a frequently used device by railway engineers to increase height in a short distance where topography is suitable.

Note: There are incomplete details for a number of items listed in NSW. The Heritage Branch intends to develop or upgrade statements of significance and other information for these items as resources become available.

## Description

**Physical Description:** STRUCTURES
underbridge - steel RSJ on concrete piers, 869.4km
tunnel - concrete 871.9km
tunnel - concrete 872.6km
crossing loop - border loop 875.1km
tunnel on border with Queensland 875.5km

spiral
LANDSCAPE
the whole section of line from Congal to the Border loop

## Assessment of Significance

**SHR Criteria f)** [Rarity] — This item is assessed as historically rare. This item is assessed as scientifically rare. This item is assessed as arch. rare.

**Assessment Criteria** — Items are assessed against the **State Heritage Register (SHR) Criteria** to determine the level of significance. Refer to the Listings below for the level of statutory protection.

## Procedures / Exemptions

| Section of Act | Description | Title | Comments | Action Date |
|---|---|---|---|---|
| 57(2) | Exemption to allow work | Standard Exemptions | SCHEDULE OF STANDARD EXEMPTIONS<br>HERITAGE ACT 1977<br>Notice of Order Under Section 57 (2) of the Heritage Act 1977<br><br>I, the Minister for Planning, pursuant to subsection 57 (2) of the Heritage Act 1977, on the recommendation of the Heritage Council of New South Wales, do by this Order:<br><br>1. revoke the Schedule of Exemptions to subsection 57(1) of the Heritage Act made under subsection 57 (2) and published in the Government Gazette on 22 February 2008; and<br><br>2. grant standard exemptions from subsection 57(1) of the Heritage Act 1977, described in the Schedule attached.<br><br>FRANK SARTOR<br>Minister for Planning<br>Sydney, 11 July 2008<br><br>To view the schedule click on the Standard Exemptions for Works Requiring Heritage Council Approval link below. | Sep 5 2008 |

**Standard Exemptions** for Works Requiring Heritage Council Approval

## Listings

| Heritage Listing | Listing Title | Listing Number | Gazette Date | Gazette Number | Gazette Page |
|---|---|---|---|---|---|
| *Heritage Act - State Heritage Register* | | 01027 | 02 Apr 99 | 27 | 1546 |
| *Heritage Act - s.170 NSW State agency heritage register* | | | | | |

## Study Details

| Title | Year | Number | Author | Inspected by | Guidelines Used |
|---|---|---|---|---|---|
| | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| State Rail Authority Section 170 Register | 1997 | SRA245 | State Rail Authority | | | No |

## References, Internet links & Images

None

Note: Internet links may be to web pages, documents or images.

## Data Source

The information for this entry comes from the following source:

**Name:** Heritage Branch

**Database Number:** 5011937

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